Radiological Health Data

VOLUME IV, NUMBER 6

June 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Health, Education, and Welfare
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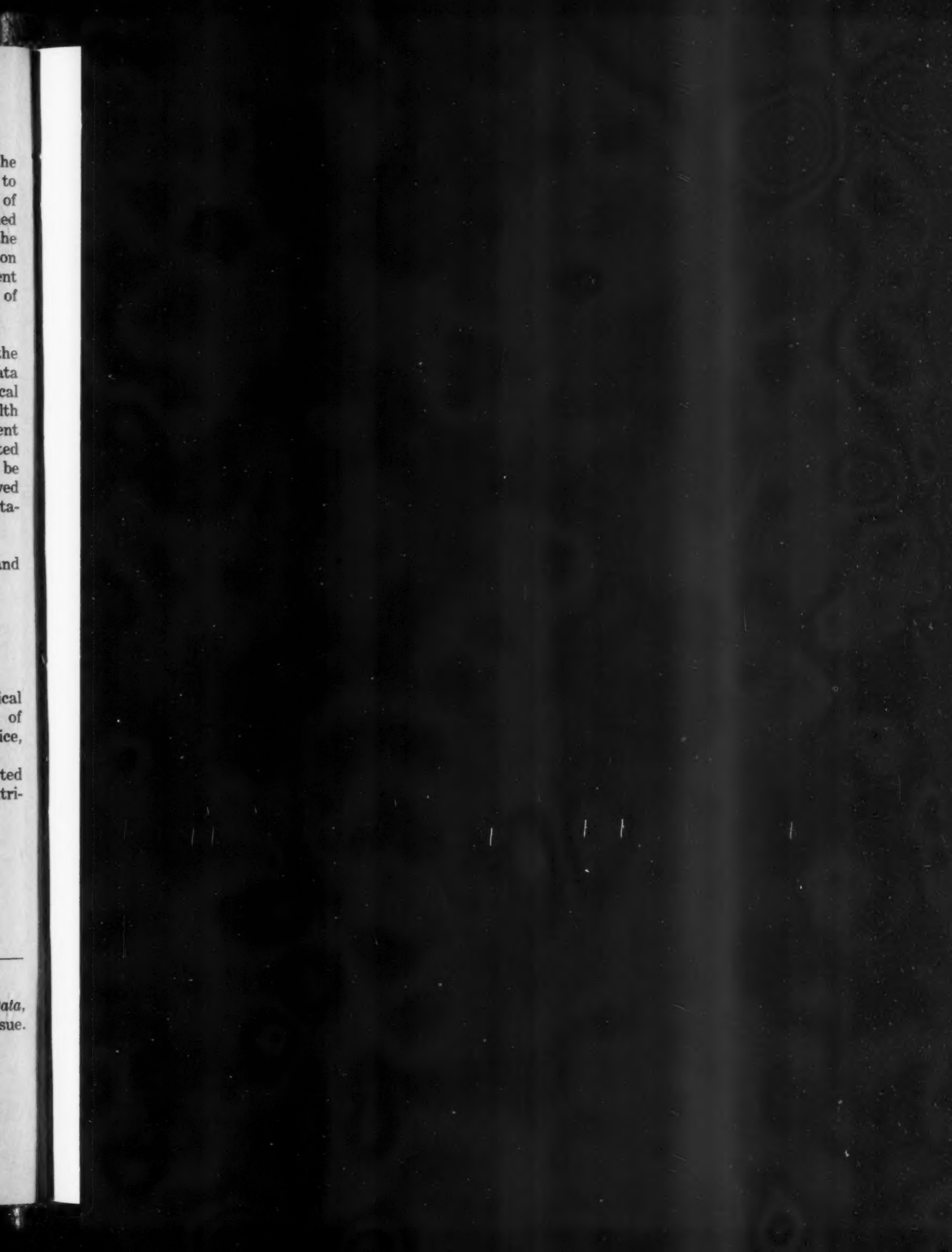
For further information on any subject reported in this issue, readers are referred to the contributors indicated in article headings.



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RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Quick and sensitive detection of fission product activity fluctuations in the environment is possible through a program of continuous surveillance of gross beta activity in air and precipitation. The information obtained through surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis of an alerting system and can be used as a rough guide for determining when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

February 1963 gross beta concentrations are presented here in reports from the Radiation Surveillance Network, Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Because of differences in equipment and techniques, the results from one network are not directly comparable with those of another. However, some intercalibration factors have been determined in a study conducted by Lockhart and Patterson of the U.S. Naval Research Laboratory (*1*, *2*). An application of the results of this study is presented in figure 3 in which the February gross beta radioactivity in air data from Canada and the U.S. were combined in one isogram map. To adjust to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCES

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D.C. (November 13, 1962).

(*2*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: Intercalibration of Some Air Monitoring Systems, *Radiological Health Data*, *3*:466–70, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1962).

RADIATION SURVEILLANCE NETWORK
February 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed among the fifty States, Guam, and Puerto Rico (see figure 1). These stations are manned predominantly by State health department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} known activity source. This determination is usually made about 5 hours after the end of collection to eliminate interference from naturally occurring radon daughters. The network's station operators contribute to a daily national report by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, FEBRUARY 1963

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. From the two counts separated by a 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula ($AT^{1.2}$ = constant).* The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The average fission-product beta concentrations in surface air during February 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1.

In order to compare these data with the gross beta reported by Canada, an adjustment is required. The relationship given by Lockhart and Patterson[1] is

$$\frac{\text{PHS}}{\text{Canada}} = 0.65 \pm 0.048 \text{ (one standard deviation)}$$

which may be written:

$$1.54 \times \text{PHS} \pm 7.4 \text{ percent} = \text{Canada}$$

It was considered more appropriate to adjust the RSN values upward to correspond with Canada's rather than to adjust the Canadian data downward. This was done in consideration of the higher filter efficiency and lower self-absorption of the Canadian system compared with that of the RSN.[1]

The Canadian air data and the adjusted RSN data have been combined in the map (figure 3), which includes most of the North American continent.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using

* In this expression, A is the activity and T is the time after fission product formation.

[1] See references (*1*) and (*2*), page 277.

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, FEBRUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station location		Number of samples	Maximum	Minimum	Average[a]
Alaska:	Adak	28	13	0.35	4.8
	Anchorage	28	10	0.76	4.8
	Attu	28	19	0.76	5.7
	Fairbanks	23	5.3	0.99	3.7
	Juneau	18	12	0.11	3.8
	Kodiak	26	28	0.19	6.0
	Nome	25	10	0.27	3.9
	Point Barrow	28	7.6	0.91	4.2
	St. Paul Island	22	7.4	0.52	4.3
Ariz:	Phoenix	25	17	3.8	9.0
Ark:	Little Rock	26	12	3.0	8.3
Calif:	Berkeley	28	9.0	1.1	3.4
	Los Angeles	18	13	2.1	6.9
Colo:	Denver	27	18	3.3	8.5
Conn:	Hartford	28	8.3	1.7	5.4
Del:	Dover	20	11	1.5	7.8
D.C:	Washington	28	8.0	2.2	4.9
Fla:	Jacksonville	28	13	1.5	6.9
	Miami	27	12	1.3	6.5
Ga:	Atlanta	24	7.8	0.61	4.8
Guam:	Agana	11	11	0.16	1.9
Hawaii:	Honolulu	28	9.0	0.24	4.0
Idaho:	Boise	27	17	1.1	7.5
Ill:	Springfield	27	11	3.1	6.2
Ind:	Indianapolis	27	9.5	3.2	6.1
Iowa:	Iowa City	27	10	2.7	5.0
Kans:	Topeka	28	9.2	0.84	5.1
Ky:	Frankfort	28	11	3.3	6.5
La:	New Orleans	28	15	2.9	6.9
Maine:	Augusta	28	10	2.8	6.7
	Presque Isle	28	6.7	3.1	4.8
Md:	Baltimore	18	12	3.0	6.7
	Rockville	12	7.6	3.2	4.9
Mass:	Lawrence	28	9.3	3.4	5.6
	Winchester	25	16	5.1	9.3
Mich:	Lansing	28	12	4.3	7.6
Minn:	Minneapolis	28	7.1	2.8	4.7
Miss:	Jackson	25	12	2.7	6.7
	Pascagoula	19	11	2.7	6.9
Mo:	Jefferson City	28	11	2.1	5.7
Mont:	Helena	27	18	1.7	7.1
Nebr:	Lincoln	8	6.8	2.2	4.0
Nev:	Las Vegas	26	24	2.2	12
N.H:	Concord	17	12	6.0	9.4
N.J:	Trenton	28	8.6	2.7	5.4
N.Mex:	Santa Fe	28	11	0.84	5.7
N.Y:	Albany	28	9.5	<0.10	5.1
	Buffalo	28	13	3.0	6.5
	New York	13	6.3	2.1	3.9
N.C:	Gastonia	28	16	3.2	9.3
N.Dak:	Bismarck	28	7.9	1.5	5.1
Ohio:	Cincinnati	20	9.3	3.3	6.1
	Columbus	28	11	3.1	6.5
	Painesville	26	12	3.8	7.4
Okla:	Oklahoma City	27	9.6	0.78	5.4
	Ponca City	25	7.2	0.47	3.5
Ore:	Portland	26	26	1.2	10
Pa:	Harrisburg	11	8.2	3.6	5.8
P.R:	San Juan	26	5.3	0.85	2.7
R.I:	Providence	28	9.8	1.9	6.6
S.C:	Columbia	25	12	1.9	5.6
S.Dak:	Pierre	28	8.1	1.4	4.8
Tenn:	Nashville	25	13	1.1	7.4
Tex:	Austin	28	14	1.4	8.0
	El Paso	26	14	1.3	7.5
Utah:	Salt Lake City	28	22	2.5	8.9
Vt:	Barre	27	13	0.82	7.7
Va:	Richmond	28	8.2	2.4	5.1
Wash:	Seattle	28	14	0.59	4.8
W.Va:	Charleston	27	10	2.9	5.8
Wisc:	Madison	27	14	3.9	7.4
Wyo:	Cheyenne	28	16	0.64	6.7
Network average					6.1

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, FEBRUARY 1963

Station location		Average concentration ($\mu\mu c$/liter)	Total deposition ($m\mu c/m^2$)
Alaska:	Adak	[a]—	—
	Anchorage	3,300	59
	Attu	—	—
	Fairbanks	2,200	8.4
	Juneau	—	—
	Kodiak	—	—
	Nome	—	—
	Point Barrow	—	—
	St. Paul Island	—	—
Ariz:	Phoenix	—	—
Ark:	Little Rock	1,200	48
Calif:	Berkeley	730	77
	Los Angeles	900	73
Colo:	Denver	—	—
Conn:	Hartford	1,300	83
Del:	Dover	—	—
D.C:	Washington	1,600	80
Fla:	Jacksonville	1,400	130
	Miami	930	72
Ga:	Atlanta	550	46
Guam:	Agana	—	—
Hawaii:	Honolulu	—	—
Idaho:	Boise	1,100	65
Ill:	Springfield	2,300	29
Ind:	Indianapolis	2,600	30
Iowa:	Iowa City	1,200	7
Kans:	Topeka	—	—
Ky:	Frankfort	1,700	36
La:	New Orleans	1,100	169
Maine:	Augusta	900	96
	Presque Isle	—	—
Md:	Baltimore	—	—
	Rockville	—	—
Mass:	Lawrence	1,000	67
	Winchester	1,900	130
Mich:	Lansing	—	—
Minn:	Minneapolis	2,700	25
Miss:	Jackson	870	37
	Pascagoula	—	—
Mo:	Jefferson City	690	0.6
Mont:	Helena	3,400	43
Nebr:	Lincoln	—	—
Nev:	Las Vegas	—	—
N.H:	Concord	—	—
N.J:	Trenton	6,800	13
N.Mex:	Santa Fe	2,600	81
N.Y:	Albany	720	24
	Buffalo	—	—
	New York	—	—
N.C:	Gastonia	750	46
N.Dak:	Bismarck	2,000	18
Ohio:	Cincinnati	—	—
	Columbus	5,100	16
	Painesville	2,500	20
Okla:	Oklahoma City	—	—
	Ponca City	—	—
Ore:	Portland	1,500	110
Pa:	Harrisburg	—	—
P.R:	San Juan	500	19
R.I:	Providence	2,200	160
S.C:	Columbia	1,700	190
S.Dak:	Pierre	—	—
Tenn:	Nashville	2,500	140
Tex:	Austin	1,200	88
	El Paso	7,700	29
Utah:	Salt Lake City	2,200	30
Vt:	Barre	1,500	69
Va:	Richmond	920	56
Wash:	Seattle	1,800	110
W.Va:	Charleston	1,200	24
Wisc:	Madison	1,700	8.1
Wyo:	Cheyenne	—	—

[a] Dash indicates no evaporated sample received.

funnels with collection areas of 0.4 square meters. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air sample, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of preciptiation is reported, but no analysis is made. February 1963 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu$c/liter) and millimicrocuries per square meter (mμc/m^2), are presented in table 2.

(*1*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
February 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation at 24 stations located at airports (see figure 2). The sampling equipment is operated by meteorologists of the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the Radioactive Fallout Study Program are contained in the Department's reports (*1–5*).

Air

In the collection of air samples, about 650 cubic meters of air are drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is removed from each filter and counted with a thin-end-window Geiger flow counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The result is extrapolated to the end of the sampling period. Canadian air data for February 1963 are given in table 3, and presented in conjunction with U.S. adjusted air data in the concentration contour map (figure 3).

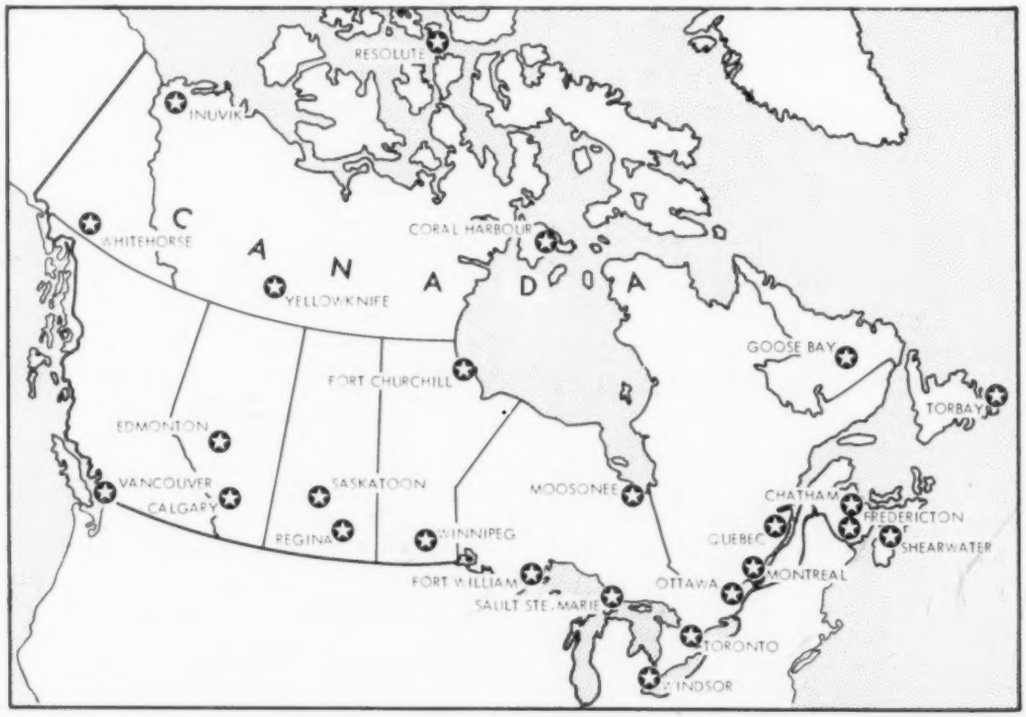

FIGURE 2.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, FEBRUARY 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, FEBRUARY 1963

[Average concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Calgary	28	24.0	0.7	9.8
Coral Harbour	28	23.0	0.1	7.7
Edmonton	21	12.3	2.5	6.5
Ft. Churchill	28	12.5	0.4	5.6
Ft. William	28	17.3	6.5	10.7
Fredericton	27	13.8	2.9	9.8
Goose Bay	27	12.0	0.8	6.9
Inuvik	28	16.0	5.3	10.1
Montreal	27	16.3	4.8	10.6
Moosonee	26	23.3	4.7	10.3
Ottawa	28	16.5	6.1	11.3
Quebec City	28	15.3	6.2	10.5
Regina	28	16.7	4.2	10.7
Resolute	22	16.5	0.6	8.4
Saskatoon	27	19.0	7.2	11.2
Sault Ste. Marie	28	21.0	7.6	11.0
Shearwater	26	18.6	6.3	13.0
Torbay	26	20.0	1.4	9.1
Toronto	28	22.0	1.1	11.1
Vancouver	28	22.0	0.8	6.3
Whitehorse	27	15.8	0.7	8.0
Windsor	27	28.0	7.4	12.8
Winnipeg	28	21.5	6.8	11.6
Yellowknife	28	19.5	5.0	10.9
Average				9.8

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. February 1963 precipitation data for Canada, including some radiochemical analyses, are shown in table 4.

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(1) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW (RP–3)*, (May 1960).

(2) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW (RP–4)*, (December 1961).

(3) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program CNHW (RP–5)*, (June 1, 1960).

(4) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, (RPD–11)*, (July 1962).

(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, (RPD–21)*, (August 1962).

Recent coverage in *Radiological Health Data:*

Period	Issue
Third quarter 1961	*May 1962*
Fourth quarter 1961	*September 1962*
First quarter 1962	*October 1962*
Second and third quarters 1962	*January 1963*
October 1962	*February 1963*
Novermber 1962	*March 1963*
December 1962	*April 1963*

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, FEBRUARY 1963

Station	Total beta activity		Deposition of specific radionuclides for selected samples[a, b] ($m\mu c/m^2$)				
	$\mu\mu c$/liter	$m\mu c/m^2$	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	1,278	10.4	1.87	0.13	1.14	0.07	0.27
Coral Harbour	[c]—	63.9					
Edmonton	3,148	72.0					
Ft. Churchill	6,808	24.2					
Fort William	2,316	37.1					
Fredericton	375	42.1					
Goose Bay	210	16.8					
Inuvik	2,683	27.3					
Montreal	2,452	144.4	15.1	0.87	22.0	2.04	2.84
Moosonee	537	21.5					
Ottawa	1,921	93.2					
Quebec	895	92.5					
Regina	2,453	30.5					
Resolute	2,177	199.0					
Saskatoon	1,442	38.4					
Sault Ste. Marie	1,006	68.0					
Shearwater	—	—					
Torbay	906	88.5					
Toronto	465	59.1					
Vancouver	2,300	331.0	39.4	1.80	45.1	3.40	5.15
Whitehorse	2,190	24.5					
Windsor	3,114	65.7					
Winnipeg	1,599	51.2	4.88	0.51	9.55	0.48	0.84
Yellowknife	2,844	35.4					
Average	1,960	71.2					

[a] All values corrected for decay back to end of collection month.
[b] Values for strontium–90, cesium–137, and zirconium–95 do not include the activities of their daughter isotopes, yttrium–90, barium–137, and niobium–95.
[c] Dash indicates no sample.

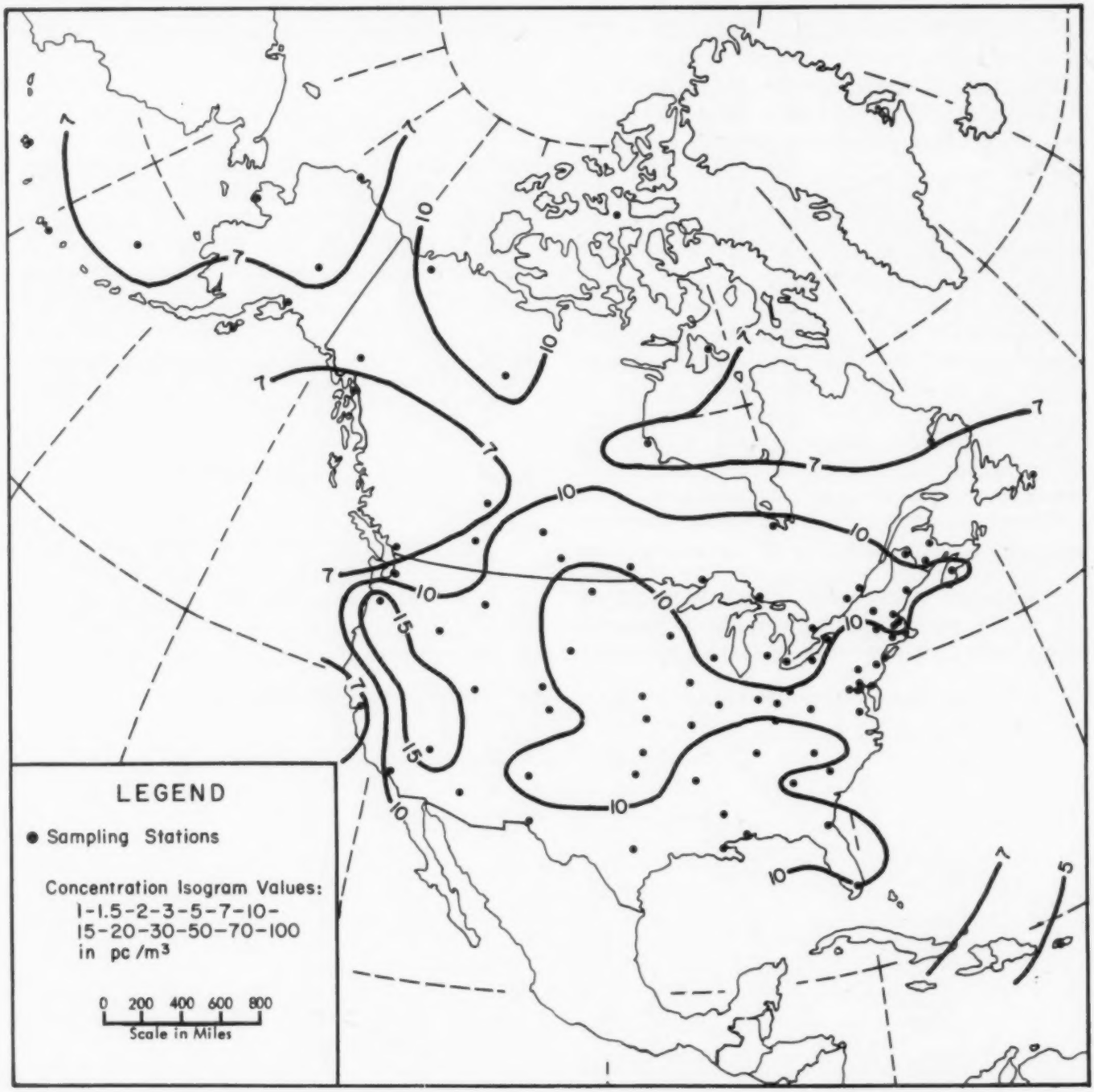

FIGURE 3.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAMS FOR CANADA AND THE U. S., FEBRUARY 1963

MEXICAN RADIOACTIVE FALLOUT PROGRAM
February 1963

Radiological Protection Program
National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comisíon Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations (see figure 4).

Eight of the twelve stations are located at airports and operated by airline personnel. The remaining four stations are located at Mexico City, Mérida, Veracruz, and San Luis Potosí. Staff members of the RPP operate the station at Mexico City, while the other three stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, and the Instituto de Zonas Desérticas of the University of San Luis Potosí, respectively.

In December 1962, the station located in Tijuana was moved to Ensenada, a city on the Pacific Coast 60 miles from Tijuana, where it is operated by the staff members of the Escuela Superior de Ciencias Marinas of the University of Baja California.

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a 6″ x 8″ high-efficiency glass fiber filter, using high-volume samplers. After each 24-hour period, the filter is removed and airmailed to the Laboratorio de Desechos Radiactivos (CNEN) in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission-product beta concentrations in surface air during February 1963 are presented in table 5.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, FEBRUARY 1963

[Concentrations in $\mu\mu c/m^3$]

Station	Number of samples	Maximum	Minimum	Average
Acapulco*				
Ciudad Juárez	5	26.2	3.5	19.7
Ensenada	2	16.3	0.9	—
Guadalajara	4	23.6	2.1	10.6
La Paz	19	14.1	1.3	6.8
Mérida	7	17.8	6.3	10.6
México, D. F.**	14	34.1	2.0	13.5
San Luis Potosí	11	38.5	4.1	12.5
Torreón	15	23.7	5.5	13.5
Tuxtla Gutierrez	15	21.3	0.7	4.8
Veracruz	19	41.6	0.7	10.4

* Out of order.
** Mexico City.

SECTION II.—FOOD

Radionuclides in Diets For Teen-agers

May 1962–February 1963

Division of Pharmacology, Food and Drug Administration

It has been estimated that among all age groups 16-19-year-old males need more food daily than any other segment of the U.S. population (*1*). Because of this, the Food and Drug Administration (FDA) chose this age group for a test of the maximum radionuclide intake of all population groups. As a basis for the test, the food plan used was that recommended by the U.S. Department of Agriculture (USDA) for a nutritionally adequate diet at moderate cost level for boys 16-19 years of age (*2*).

The FDA study of radionuclides in diets for teen-agers was begun on a pilot basis in May 1961 in the Washington, D.C., area. Since then, the program has been expanded to include 4 other cities—San Francisco, Minneapolis, St. Louis, and Atlanta. Samplings are being made quarterly.

By selecting the 16-19-year-old male, who daily needs 3,600 calories well-laced with protein, minerals, and vitamins, compared with 3,200 calories and smaller amounts of nutrients needed by the "standard" man, the radionuclide intake in U.S. diets can be conservatively estimated. For the purposes of the sampling program, amounts of the detailed foods selected from the 11 food groups of the USDA plan were proportioned according to the 1955 Household Food Consumption Survey (*3*).

Procedures

To duplicate the diet of a 19-year-old male, a list of 82 different items of food and drink was prepared. The amounts of these items, covering a two-week consumption period, were purchased from national food chain stores. Among the food sources sampled the variation of radionuclide concentration within a particular food was found to be statistically insignificant. Every effort was made to locate the source of the food items and arrange representation in the sample on as broad a geographical basis as possible.

The food was prepared by professional dietitians at the National Institutes of Health in a manner comparable to domestic preparation procedure. The most acceptable home practices for washing, trimming, bone removal, and separation of wastes and cooking water were used. Meats, fish, and chicken were broiled before removing the bones. Some fruits and vegetables were prepared as raw servings while others were cooked. Canned foods and raw frozen fruits were used as is. Coffee and tea were brewed. Certain cereals, such as rice and oatmeal, and macaroni were cooked in water. Representative portions of each food (including drinking water) were homogenized into a slurry, and aliquots were analyzed for strontium-90.

TABLE 1.—STRONTIUM-90 CONCENTRATIONS IN THE TOTAL DIET (INCLUDING DRINKING WATER)

Sampling locations	May 1963		August 1962		November 1962		February 1963	
	pc/kg	pc/day*	pc/kg	pc/day*	pc/kg	pc/day*	pc/kg	pc/day*
San Francisco, Calif	3.0	11.3	3.4	12.8	4.8	18.1	8.0	30.1
Washington, D. C	6.4	24.0	6.9	26.0	8.4	31.6	12.0	45.1
Atlanta, Ga	9.7	36.4	7.2	27.1	9.2	34.6	12.5	47.1
Minneapolis, Minn	5.2	19.5	9.0	33.8	7.9	29.7	8.8	33.1
St. Louis, Mo	10.0	37.6	8.8	33.1	9.5	35.7	7.1	26.7

* Estimated intake for the 19-year age group.

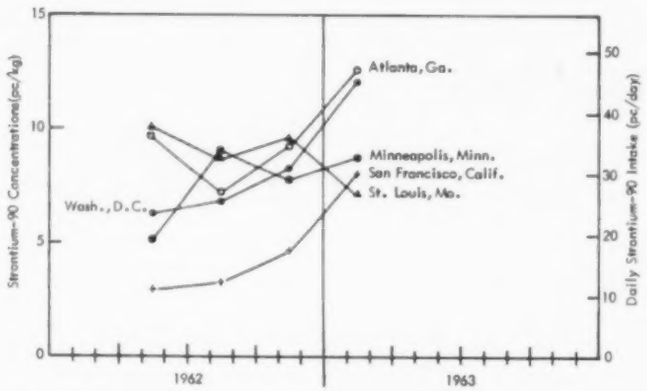

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN THE TOTAL DIET (INCLUDING DRINKING WATER)

The average strontium-90 concentrations in the diet for the five cities surveyed are presented in table 1. Through reanalysis of some samples, data previously presented in *Radiological Health Data* have been corrected. All confirmed values are presented in table 1. These data are presented graphically in figure 1.

Discussion

Since May 1962, and extending throughout 1962, strontium-90 concentrations have ranged between 3 and 10 pc/kg of food. Notable is the fact that San Francisco had the lowest values.

All cities except St. Louis showed an increase in strontium-90 concentrations in February 1963 over the November 1962 values. Percentagewise, the largest increases from November to February were in Atlanta, Washington, D.C., and San Francisco.

Using a consumption factor of 3.76 kilograms/day, it is apparent that the daily intake of strontium-90 at Atlanta for February 1963 was 47 pc/day. This is the largest intake at any of the five cities at any time since the beginning of this program in May 1962 and represents about 25 percent of the Federal Radiation Council Range II maximum for strontium-90 of 200 pc/day.

Previous coverage in *Radiological Health Data:*

Period	Issue
May–August 1962	*January 1963*

REFERENCES

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(2) U.S. Department of Agriculture: *Family Food Plans and Food Costs, Home Economics Research Report No. 20*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (November 1962), price $.35.
(3) U.S. Department of Agriculture: *Food Consumption of Households in the United States, Report No. 1 (1955)*, Household Food Consumption Survey. Superintendent of Documents, Government Printing Office, Washington 25, D.C. (December 1956), price $1.00.

Strontium-90 in Canadian Wheat, 1957-1961[1]

H. Taniguchi[2]

A comprehensive program for the measurement of strontium-90 in Canadian wheat was started in 1959 by the Radiation Protection Division of the Canadian Department of National Health and Welfare, with the assistance of the Department of Trade and Commerce and Atomic Energy of Canada Limited. The actual sampling for the program was planned and carried out by the Grain Research Laboratory and the Grain Inspection Branch of the Board of Grain Commissioners for Canada.

The major wheat growing areas for hard red spring wheat were divided into nine districts as shown in figure 1.

At the end of a crop year, ten pounds of wheat were obtained from each district. Each sample was a composite of a large number of smaller samples obtained within a district, weighted according to production, and was closely representative of all wheat produced in that district.

Method of Analysis

The method of analysis and results for a variety of samples of stored wheat from the 1957 and 1958 crop years and of wheat exported from the Pacific and Atlantic seaboard ports have been reported from the Low Level Laboratory of Atomic Energy of Canada Limited at Deep River, Ontario, by Grummitt and Robertson (*1*).

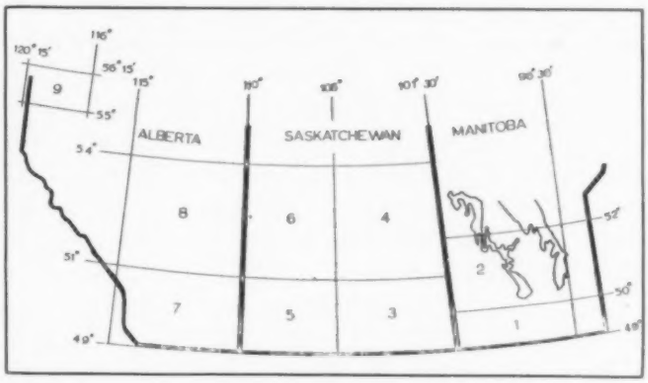


FIGURE 1.—WHEAT SAMPLING DISTRICTS OF CANADA

The method was adapted from the procedure used for strontium-90 determinations in milk (*2*, *3*). In most cases, 500 grams of each composite were taken. These samples, as received, were throughly heated at 200° C and dry-ashed at 600° C to a white residue. The resulting ash was leached with 6 N hydrochloric acid in the presence of strontium carrier. The strontium fraction was isolated by elution with 6 N hydrochloric acid from a cation exchange column after the calcium had been removed by eluting with ammonium lactate. Yttrium-90 resulting from this further purified strontium fraction was then separated and counted. The chemical recovery of strontium carrier was corrected for the natural strontium content of the sample, assuming an average correction of 3 percent (*1*). A portion of the hydrochloric acid leach was analyzed for calcium by double precipitation of the oxalate and titration of the oxalate with potassium permanganate in the presence of sulphuric acid.

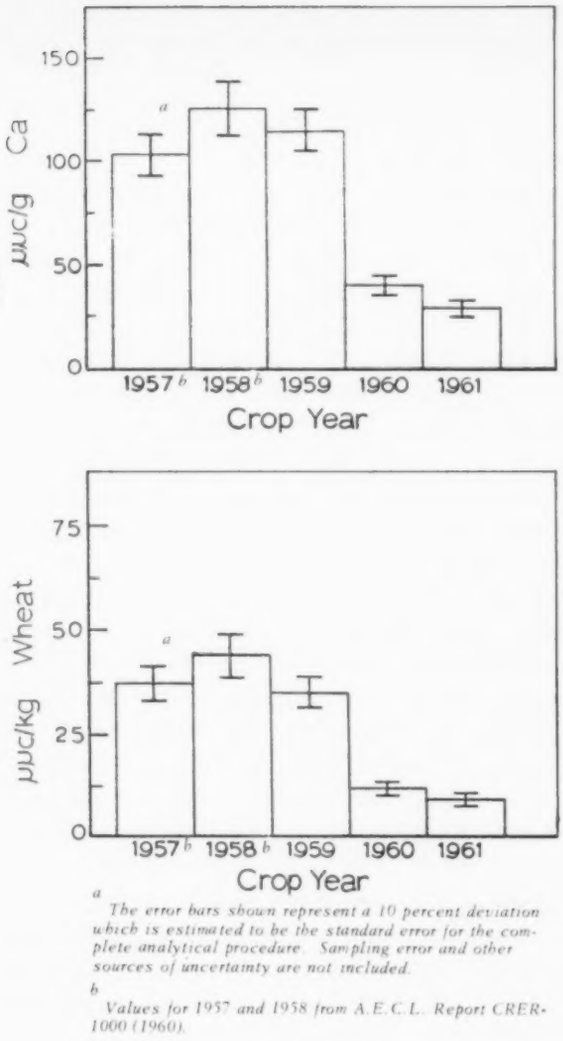
Aliquots of samples of the 1959 crop year, which were collected under the present sampling arrangement, were analyzed in the laboratory of Atomic Energy of Canada Limited as well as in the Radiation Protection Division's laboratory to verify that the overall procedure was comparable. The average deviation of independent duplicate analyses in the Radiological Protection Division's laboratory was 1.1 $\mu\mu$c/kg wheat and the average deviation between the analyses in the two laboratories was 2.1 $\mu\mu$c/kg wheat with both positive and negative deviations. This is well within the 6 percent standard error found for similar analyses of milk powder (*4*).

Results and Discussion

The results of the analyses of whole wheat for the crop years 1959, 1960, and 1961 are presented in table 1. Strontium-90 values in wheat for the years 1957 through 1961 are presented graphically in figure 2. The estimated production figures, supplied by the Grain Research Laboratory, were used to calculate the reported weighted averages. Where there was a significant delay between sampling and analysis, the values were corrected

[1] Data abstracted from the *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW (RP–5)*, (December, 1962), of the Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada.

[2] Dr. Taniguchi is Radiochemist with the Radiation Protection Division of the Canadian Department of National Health and Welfare, 370 Sparks Street, Ottawa 4, Ontario, Canada.



a The error bars shown represent a 10 percent deviation which is estimated to be the standard error for the complete analytical procedure. Sampling error and other sources of uncertainty are not included.

b Values for 1957 and 1958 from A.E.C.L. Report CRER-1000 (1960).

FIGURE 2.—STRONTIUM-90 IN CANADIAN WHEAT

for decay of strontium-90 to September of the year in which the wheat was grown.

The values in table 1 show no appreciable differences in the strontium-90 content of Canadian wheat in 1959 as compared with 1957 or 1958. In 1957, the mean values of a composite representing production for that year were 103 ± 10 μμc/g calcium and 37 ± 4 μμc/kg wheat, and in 1958 the corresponding figures were 125 ± 13 μμc/g calcium and 44 ± 5 μμc/kg wheat (*1*). During 1959, the weighted average strontium-90 values were 114 μμc/g calcium and 35 μμc/kg wheat. Within the limits of the analytical error, this change is not significant.

However, the strontium-90 level in wheat harvested during 1960 fell to a value of 40.8 μμc/g calcium and 12.0 μμc/kg wheat, or about one-third of the previous year's values. In 1961, there was a further decrease, as the value fell to 29 μμc/g calcium and 9.5 μμc/kg wheat. One anomaly was noted; unlike the other districts, district 7 showed an increase in 1961 over 1960 (when the strontium-90 activity is expressed as μμc/kg of wheat). However, the increase was small (14 percent) and indeed, when the levels are expressed in μμc/gram of calcium, the 1961 value is found to be less than that of 1960 for the district 7 sample as well.

The overall decrease in the amounts of strontium-90 found in wheat, in spite of the gradual increase of strontium-90 deposited on the soil, may be attributed to two factors. One factor may be a "fixation" of strontium-90 in soil minerals, thus making it progressively less available to the growing plant. The other factor may be the ability

TABLE 1.—STRONTIUM-90 AND CALCIUM IN CANADIAN WHEAT, 1959–1961

Identification of data	Year	Districts									Calculated weighted mean
		1	3	5	7	2	4	6	8	9	
		Latitude									
		49–50°	49–50°			50–52°	51–54°			55–60°	
Strontium-90 (pc/g Ca)	1959	121	64	54	114	119	129	108	185	114	114
	1960	46	31	27	36	44	40	37	69	47	40.8
	1961	20	17	19	34	15	15	21	54	44	29.3
Strontium-90 (pc/kg wheat)	1959	33	20	18	37	34	39	37	57	30	35.2
	1960	11	8	10	12	12	11	12	21	13	12.0
	1961	6	6	7	13	6	5	7	17	13	9.5
Calcium (mg/kg wheat)	1959	272	316	332	322	288	304	334	306	266	310
	1960	250	260	360	318	264	284	327	308	273	295
	1961	306	329	367	384	368	340	347	310	260	333
Production (in millions of bushels rounded).	1959	33.8	50.4	35.5	35.0	17.9	70.7	47.8	51.6	7.4	[a]350.0
	1960	34.7	93.5	46.0	22.9	18.5	68.2	64.8	58.4	7.4	[a]414.4
	1961	16.9	22.2	13.4	16.0	8.2	21.8	34.5	44.2	9.2	[a]186.4

[a] Total.

of the aboveground parts of the wheat plant to absorb fallout elements directly, rather than through the root system. The amount found in the harvested grain probably depends upon the rate of deposition of fallout during the period of growth as well as upon the accumulated strontium-90 in the soil.

It must be emphasized that the reported values are for whole wheat, not wheat flour. This is significant because much of the strontium-90 is in the bran fraction. For example, Grummitt and Robertson (*1*) found that the amount of strontium-90 in white flour milled from wheat harvested in 1957 and 1958 was less than that in whole wheat by a factor of 8 on a weight basis (a factor of 3.3 relative to calcium). The corresponding ratios between bran and flour from wheat harvested in other years are not available.

Acknowledgments

The collection and composition of the samples were arranged by Dr. J. A. Anderson, of the Grain Research Laboratory, Winnipeg. The advice and assistance received from Dr. W. E. Grummitt and G. Lahaie, of Atomic Energy of Canada Limited, in the radiochemical analyses are gratefully acknowledged. The analyses in the Radiation Protection Division Laboratory were carried out by G. E. Holmes and J. M. Quinn.

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(*2*) Grummitt, W. E., and Gwen M.Milton: *Radioche mical Procedures for Strontium and Yttrium, Atomic Energy of Canada Limited, Report CRC–688* (1957).
(*3*) Mar, P. G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powder for Strontium and Yttrium, Department of National Health and Welfare, Report RPD–5* (1960).
(*4*) Grummitt, W. E., A. P. James, and H. B. Newcombe: *The Analysis of Strontium-90 Levels in Canadian Milk Up to 1958, Atomic Energy of Canada Limited, Report CRC–850* (1959).

Tri-City Diet Study*

August–September 1962

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

Since March 1960 the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods, representing 19 food categories, are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data from the "Household Food Survey of 1955" are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is de-boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the wasted food.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in HASL-113 (*1*).

Results obtained from the tenth sampling of foods (August–September 1962) are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Discussion

The strontium-90 concentration of milk obtained in New York City during June 1962

* *Fallout Program Quarterly Summary Report, HASL–135:* 269–272, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1963), price $3.50.

TABLE 1.—AVERAGE PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE—TENTH SAMPLING

Food category	Average U. S. consumption		New York City August 1962		Chicago October 1962		San Francisco September 1962	
	kg/yr	Calcium (g/yr)	μμc/kg	μμc/yr	μμc/kg	μμc/yr	μμc/kg	μμc/yr
Bakery products	37	37.0	9.4 ± 0.7	346	22.0 ± 1.1[a]	813	6.7 ± 0.9[a]	248
Whole grain products	11	10.0	14.1 ± 1.0	155	17.0 ± 1.3	187	11.0 ± 1.2	121
Eggs	16	9.1	1.3 ± 0.1	20	5.3 ± 0.2	85	2.6 ± 0.1	202
Fresh vegetables	43	15.0	9.3 ± 0.4	398	12.0 ± 0.4	514	2.2 ± 0.5	95
Root vegetables	17	6.1	7.1 ± 0.5	121	4.9 ± 0.2	83	2.1 ± 0.3	36
Milk	221	234.3	16.2 ± 0.5	3,580	7.6 ± 0.4	1,670	3.4 ± 0.4	751
Poultry	17	9.2	0.8 ± 0.1	13	2.1 ± 0.1	36	1.7 ± 0.2	29
Fresh fish	8	10.8	0.3 ± 0.1	2	1.8 ± 0.2	14	0.9 ± 0.4	7
Flour	43	8.6	4.5 ± 0.2	195	14.8 ± 0.3	635	4.8 ± 0.3	206
Macaroni	3	0.7	4.6 ± 0.2	14	8.5 ± 0.3	25	3.8 ± 0.3	11
Rice	3	1.1	1.5 ± 0.3	5	3.0 ± 0.4	9	0.8 ± 0.4	2
Meat	73	10.9	0.7 ± 0.1	52	6.7 ± 0.1	488	1.0 ± 0.1	73
Shellfish	1	0.8	2.8 ± 1.7	3	6.6 ± 0.1	7	0.9 ± 0.2	1
Dried beans	3	2.9	2.4 ± 1.2	7	16.8 ± 1.7	50	7.0 ± 1.4	21
Fresh fruit	68	13.6	1.9 ± 0.3	129	4.6 ± 0.4	316	0.5 ± 0.3	34
Potatoes	45	5.8	5.5 ± 0.6	249	1.9 ± 0.4	87	4.4 ± 0.5	198
Canned fruit	26	1.3	1.3 ± 0.1	32	0.5 ± 0.1	12	0.7 ± 0.1	18
Fruit juices	19	1.7	1.8 ± 0.1	34	3.9 ± 0.3	73	2.9 ± 0.4	55
Canned vegetables	20	4.2	3.7 ± 0.2	75	7.7 ± 0.5	154	1.0 ± 0.5	20
Annual intake	674	383		5,430		5,258		2,128
μμc Sr^{90}/g Ca in total diet				14.1		13.7		5.6

[a] Values are one standard deviation errors due to counting.

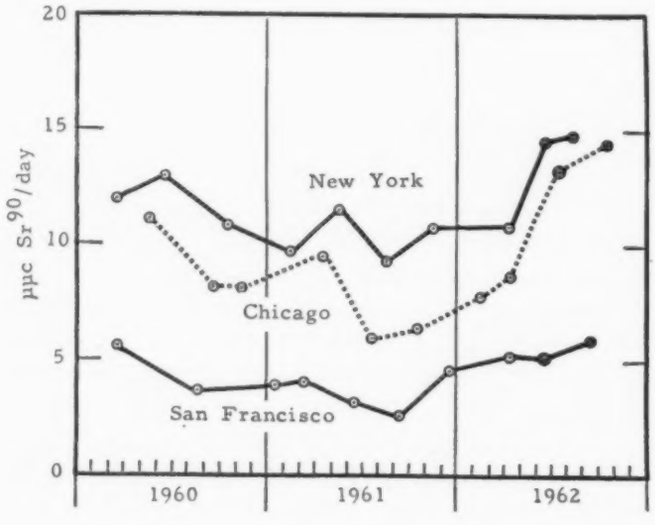

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

(*Radiological Health Data*, March 1963, page 130–1) has been revised on the basis of a re-analysis of the sample. The old value of 9.0 μμc/kg has been changed to 15.1 μμc/kg. This change requires the estimated annual intake of strontium-90 in New York City for June 1962 to be changed from 4,029 to 5,380 μμc (11.0 μμc/day to 14.7 μμc/day). Comparing this revised estimate of intake with the calculated intake from the August sampling of foods, we see that there was no increase in the estimated intake of strontium-90 at New York City between June and August 1962. This was not the case for Chicago and San Francisco, where increases of about 10 percent were noted in the estimated strontium-90 intakes between the ninth and tenth samplings.

The previously noted geographic pattern of distribution of strontium-90 in foods is seen to persist in the last sampling: New York City has the highest levels, San Francisco the lowest, while Chicago has intermediate levels. During this tenth sampling, New York City had the highest strontium-90 daily intake (14.9 μμc/day) that has been estimated for any of the cities since the tri-city diet surveys began.

Partly due to its high annual consumption, milk continues to be the predominant source of strontium-90 in the diet.

Recent coverage in *Radiological Health Data:*

Period	Issue
Fifth sampling (May–July 1961)	*March 1962*
Sixth sampling (August–October 1961)	*June 1962*
Seventh sampling (November 1961–February 1962)	*September 1962*
Eighth sampling (April 1962)	*January 1963*
Ninth sampling (June–July 1962)	*March 1963*

REFERENCE

(1) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–113*, Office of Technical Services, Department of Commerce, Washington 25, D.C (July 1, 1961), price $2.50.

SECTION III.—MILK

Milk Surveillance

Milk is the single food item most often used as an indicator of the population's intake of radionuclides from the environment, although it is only one of the many sources of dietary intake of radionuclides. A number of factors account for its use as an indicator food. For example, milk is consumed by a large proportion of the U.S. population. It is produced on a regular basis throughout the country, and it is more easily sampled and analyzed than most other foods. Further, because milk tank trucks collect and pasteurizing plants process milk from a number of producers, milk subsamples from individual plants, when properly composited, are representative of the milk consumed in a marketing area, and the radionuclide concentrations of these composited samples are indicative of radionuclide fallout over the milk producing area.

PASTEURIZED MILK NETWORK
February 1963

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a 12-station raw milk monitoring network, which was established by the Service in 1957. One of the primary objectives of this earlier network was to develop methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a 46-station pasteurized milk sampling program in July 1960. The 46 stations were selected to provide general national coverage of milk production areas and the consuming population.

As further needs developed, more milk sampling points were added, up to July 1962, when the present number of 62 stations was reached. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. After collection, the composities are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analyses. Approximately 3–6 days after sample collection, any results from gamma analyses of iodine-131 which indicate concentrations of this radionuclide greater than 100 $\mu\mu$c/liter are made available to State public health officials and the Federal Radiation Council for possible public health action. Publication of the radioanalyses of milk in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, analysis of radiostrontium, data compilation and publication procedures.

Sampling and Compositing Prodecures

The method of compositing specifies that each station's sample be composited of subsamples

from each milk processing plant in proportion to the plants sales in the communities served. The composited samples from each of the 62 stations reflects from 80 to 100 percent of the milk processed in each city. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in September 1961 and continuing through January 1963, sampling was done twice a week. During February 1963, sampling at most stations was reduced to once a week.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require re-evaluation and adjustment of the sampling frequency and analytical schedule for this program.

Analytical Errors

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-89 and strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurement of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the counting rate and counting time, the interferences from other radionuclides, and the background counting rate. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 minutes for low background beta determinations are used. Table 1 shows the approximate total laboratory analytical error associated with different radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined to be that concentration at which the 2σ analytical error is 100 percent. Therefore, the minimum detectable concentrations in units of $\mu\mu$c/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

Data Presentation

Table 2 presents a summary of all available analyses for February 1963 (January 27–February 23, 1963). When a laboratory reports that the concentration of a radiounuclide is below the minimum detectable value, one-half of this value is used in calculating the monthly average and the network average. Although no data are presented on stable potassium concentrations in milk, analyses have indicated that the usual range is from 1.4 to 1.7 grams/liter. In February, for example, 15, 23, 21 and 2 stations were reported to have respective monthly average potassium concentrations of 1.4, 1.5, 1.6, and 1.7 grams/liter of milk.

Figure 1 and 2 show the approximate occurrence of monthly U.S. average estimated strontium-89 and strontium-90 concentrations in milk. The value printed beside each station is the monthly average concentration for that station. Table 3 shows the numerical distribution of stations according to ranges of radionuclide concentrations in milk for February.

Discussion of Data

Of the 62 sampling stations, 42 showed monthly average concentrations of strontium-89 in milk for February 1963 of 20 $\mu\mu$c/liter or below (table 2). The Southeast, from South Carolina to Florida and west to eastern Texas, had strontium-89 concentrations of 50 to 200 $\mu\mu$c/liter (figure 1). Jackson, Mississippi, and New Orleans, Louisiana, had strontium-89 concentrations of 210 and 270 $\mu\mu$c/liter, respectively.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH TYPICAL CONCENTRATIONS OF SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration ($\mu\mu$c/liter)	Error, $\pm 2\sigma$ (percent of concentration)	Estimated concentration ($\mu\mu$c/liter)	Error, $\pm 2\sigma$ (percent of concentration)	Estimated concentration ($\mu\mu$c/liter)	Error, $\pm 2\sigma$ (percent of concentration)
Iodine-131	10	±100%	20	±50%	100	±10%
Barium-140	10	±100%	20	±50%	100	±10%
Cesium-137	5	±100%	10	±50%	100	±10%
Strontium-89	5	±100%	10	±50%	100	±10%
Strontium-90	1	±100%	2	±50%	20	±10%

In February, high monthly average strontium-90 concentrations in milk were noted in the same areas as they were in January. In general, levels in the Southwest were below 5 $\mu\mu$c/liter, while monthly averages in the east ranged from 20 to 36 $\mu\mu$c/liter (figure 2).

Iodine-131 monthly averages were lower in February 1963 than they were for several previous months. Forty stations were found to have levels of less than 10 $\mu\mu$c/liter for the month (table 2) while only 22 stations had values this low in January. The highest February iodine-131 average, observed at two of the stations, was 30 $\mu\mu$c/liter.

Monthly average cesium-137 concentrations in milk ranged from 25 to 135 $\mu\mu$c/liter during February 1963. The range of values seen at the greatest number of stations (26 stations) was 60 to 75 $\mu\mu$c/liter (table 3). Barium-140 averages ranged

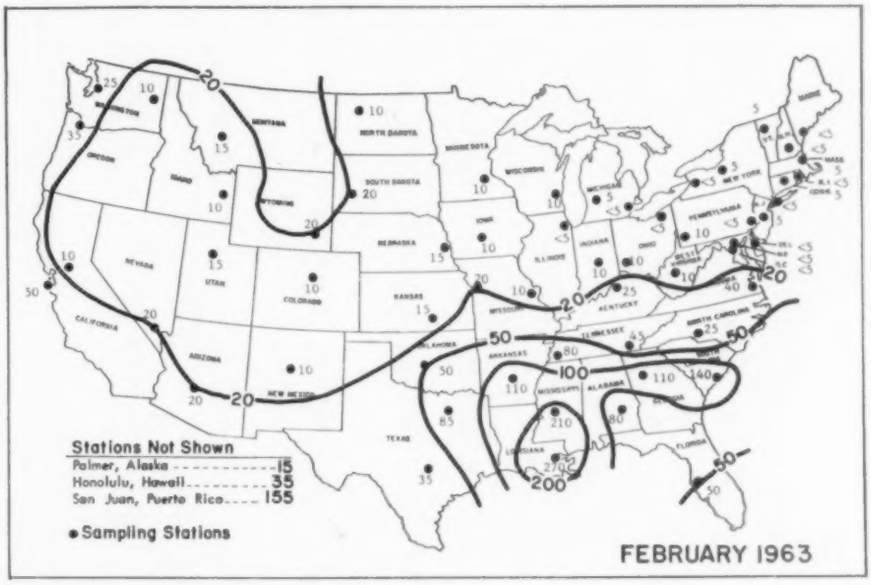

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

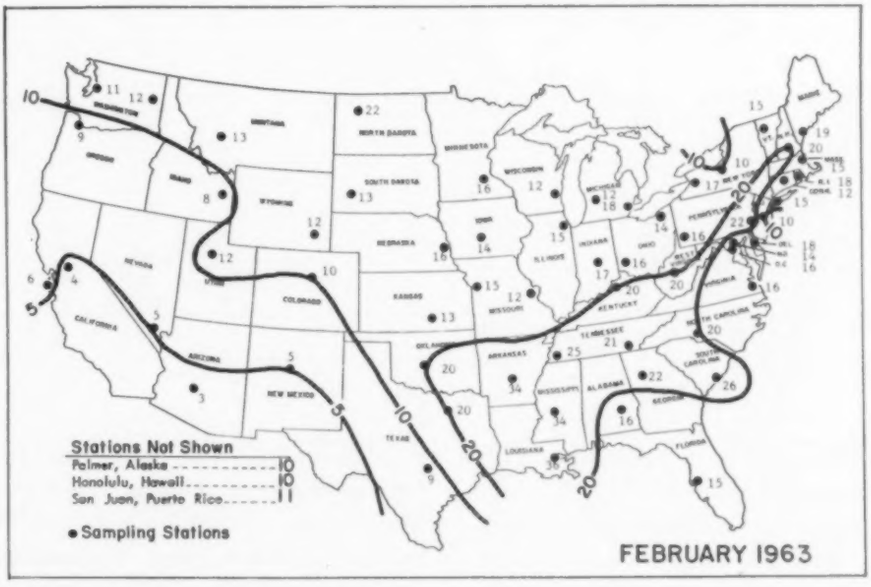

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, FEBRUARY 1963

[Average radioactivity concentrations in μμc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month	Fourth quarter 1962	Avg. for month
Ala:	Montgomery	1.26	1.27	40	80	15	16	40	<10	35	45	20	<10
Alaska:	Palmer	1.33	1.20	80	15	13	10	110	<10	60	60	30	20
Ariz:	Phoenix	1.32	1.21	25	20	5	3	20	<10	20	25	<10	10
Ark:	Little Rock	1.26	1.25	120	110	29	34	110	20	70	90	30	20
Calif:	Sacramento	1.32	1.21	20	10	4	4	20	<10	20	30	10	30
	San Francisco	1.34	1.23	20	50	4	6	20	<10	20	35	<10	10
Colo:	Denver	1.34	1.28	20	10	11	10	20	<10	55	70	<10	10
Conn:	Hartford	1.13	1.08	40	5	11	12	40	<10	65	65	10	10
Del:	Wilmington	1.11	1.08	50	<5	15	18	80	10	70	70	20	<10
D.C:	Washington	1.20	1.23	40	<5	18	16	60	<10	55	60	20	<10
Fla:	Tampa	1.25	1.27	30	50	10	15	50	20	125	135	10	<10
Ga:	Atlanta	1.24	1.25	55	110	17	22	60	10	55	90	20	20
Hawaii:	Honolulu	1.26	1.16	20	35	6	10	20	20	40	60	<10	20
Idaho:	Idaho Falls	1.31	1.32	25	10	13	8	40	<10	75	80	10	10
Ill:	Chicago	1.12	1.12	45	<5	12	15	70	<10	65	70	10	<10
Ind:	Indianapolis	1.17	1.11	50	10	13	17	80	<10	55	60	10	<10
Iowa:	Des Moines	1.36	1.22	75	10	14	14	110	<10	50	75	20	20
Kans:	Wichita	1.34	1.22	55	15	13	13	70	<10	40	55	20	20
Ky:	Louisville	1.23	1.23	95	25	23	20	80	<10	45	55	40	<10
La:	New Orleans	1.28	1.28	70	270	24	36	70	30	60	130	20	40
Maine:	Portland	1.15	1.14	50	<5	17	19	50	<10	110	105	20	<10
Md:	Baltimore	1.22	1.24	40	<5	17	14	60	<10	60	60	20	<10
Mass:	Boston	1.13	1.09	60	5	19	15	50	<10	110	90	20	<10
Mich:	Detroit	1.13	1.14	50	<5	15	18	70	<10	75	80	20	<10
	Grand Rapids	1.18	1.11	35	5	12	12	50	10	65	80	10	<10
Minn:	Minneapolis	1.32	1.20	70	10	23	16	70	<10	95	125	30	20
Miss:	Jackson	1.30	1.33	90	210	19	34	70	20	45	80	30	30
Mo:	Kansas City	1.33	1.21	100	20	17	15	120	<10	45	60	30	20
	St. Louis	1.35	1.24	55	10	14	12	60	<10	45	65	20	30
Mont:	Helena	1.35	1.20	45	15	16	13	80	10	85	105	30	20
Nebr:	Omaha	1.37	1.24	60	15	15	16	90	<10	55	80	20	20
Nev:	Las Vegas	1.26	1.23	25	20	6	5	10	<10	40	50	<10	20
N.H:	Manchester	1.16	1.13	50	<5	18	20	40	20	115	105	10	10
N.J:	Trenton	1.12	1.12	45	5	13	10	60	<10	65	60	20	<10
N. Mex:	Albuquerque	1.33	1.22	20	10	5	5	30	<10	25	30	20	20
N.Y:	Buffalo	1.10	1.10	40	<5	13	17	40	<10	80	80	10	<10
	New York	1.13	1.09	55	<5	17	15	80	<10	75	65	20	<10
	Syracuse	1.14	1.08	45	5	14	10	50	<10	65	65	10	<10
N.C:	Charlotte	1.27	1.30	50	25	19	20	20	<10	50	60	20	<10
N. Dak:	Minot	1.34	1.16	60	10	27	22	60	<10	75	85	20	20
Ohio:	Cincinnati	1.16	1.08	60	10	17	16	90	10	45	60	10	<10
	Cleveland	1.16	1.10	50	<5	14	14	70	<10	60	60	<10	<10
Okla:	Oklahoma City	1.21	1.24	65	50	17	20	100	10	40	55	20	<10
Ore:	Portland	1.40	1.22	150	35	18	9	60	<10	80	75	40	20
Pa:	Philadelphia	1.13	1.10	45	<5	14	22	80	<10	60	65	10	<10
	Pittsburgh	1.14	1.07	55	10	19	16	110	10	80	80	20	<10
P.R:	San Juan	1.17	1.19	75	155	10	11	30	30	45	75	10	20
R.I:	Providence	1.11	1.09	45	<5	16	18	60	10	85	70	20	<10
S.C:	Charleston	1.26	1.29	50	140	20	26	40	20	60	85	20	20
S. Dak:	Rapid City	1.17	0.92	50	20	15	13	70	10	70	80	20	10
Tenn:	Chattanooga	1.28	1.31	95	45	20	21	60	<10	50	65	30	<10
	Memphis	1.25	1.28	85	80	20	25	80	<10	40	50	30	10
Tex:	Austin	1.23	1.23	35	35	8	9	90	<10	30	30	20	<10
	Dallas	1.23	1.26	90	85	16	20	150	20	45	60	30	20
Utah:	Salt Lake City	1.35	1.26	30	15	11	12	40	10	75	110	30	20
Vt:	Burlington	1.11	1.08	55	5	13	15	60	<10	85	85	20	<10
Va:	Norfolk	1.23	1.28	45	40	20	16	50	<10	60	65	20	<10
Wash:	Seattle	1.36	1.24	100	25	21	11	60	<10	85	85	40	20
	Spokane	1.40	1.36	35	10	15	12	30	10	80	95	10	20
W. Va:	Charleston	1.22	1.24	60	10	21	20	40	10	55	50	20	<10
Wis:	Milwaukee	1.18	1.10	45	10	11	12	90	10	70	60	20	<10
Wyo:	Laramie	1.32	1.23	45	20	12	12	20	<10	80	110	10	30
Network average		1.24	1.19	55	33	15.1	1.54	61	<10	62	72	19	13

between < 10 and 40 μμc/liter in February, with 29 stations reporting < 10 μμc/liter.

The radionuclide levels observed in milk during February may be partially explained by such factors as cattle feeding practices. The *Weekly Weather and Crop Bulletin* (*1*) showed that supplemental feeding and pasturage were about normal for this time of year in the Great Plains. In the Mississippi Valley, Gulf, and South Atlantic States, below-normal temperatures held back development of pastures so that supplemental feeding was above normal during February.

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN SELECTED RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, FEBRUARY 1963

Strontium–89		Strontium–90		Iodine–131		Cesium–137		Barium–140	
Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations	Range (μμc/liter)	Number of stations
<5	12	<1– 5	4	<10	40	<5– 15	0	<10	29
5– 20	30	6–10	9	10	13	20– 35	5	10	8
25– 40	7	11–15	21	20	7	40– 55	7	20	20
45– 60	4	16–20	19	30	2	60– 75	26	30	4
65– 80	2	21–25	5			80– 95	16	40	1
85–100	1	26–30	1			100–115	5		
105–200	4	31–35	2			120–135	3		
>200	2	36–40	1						

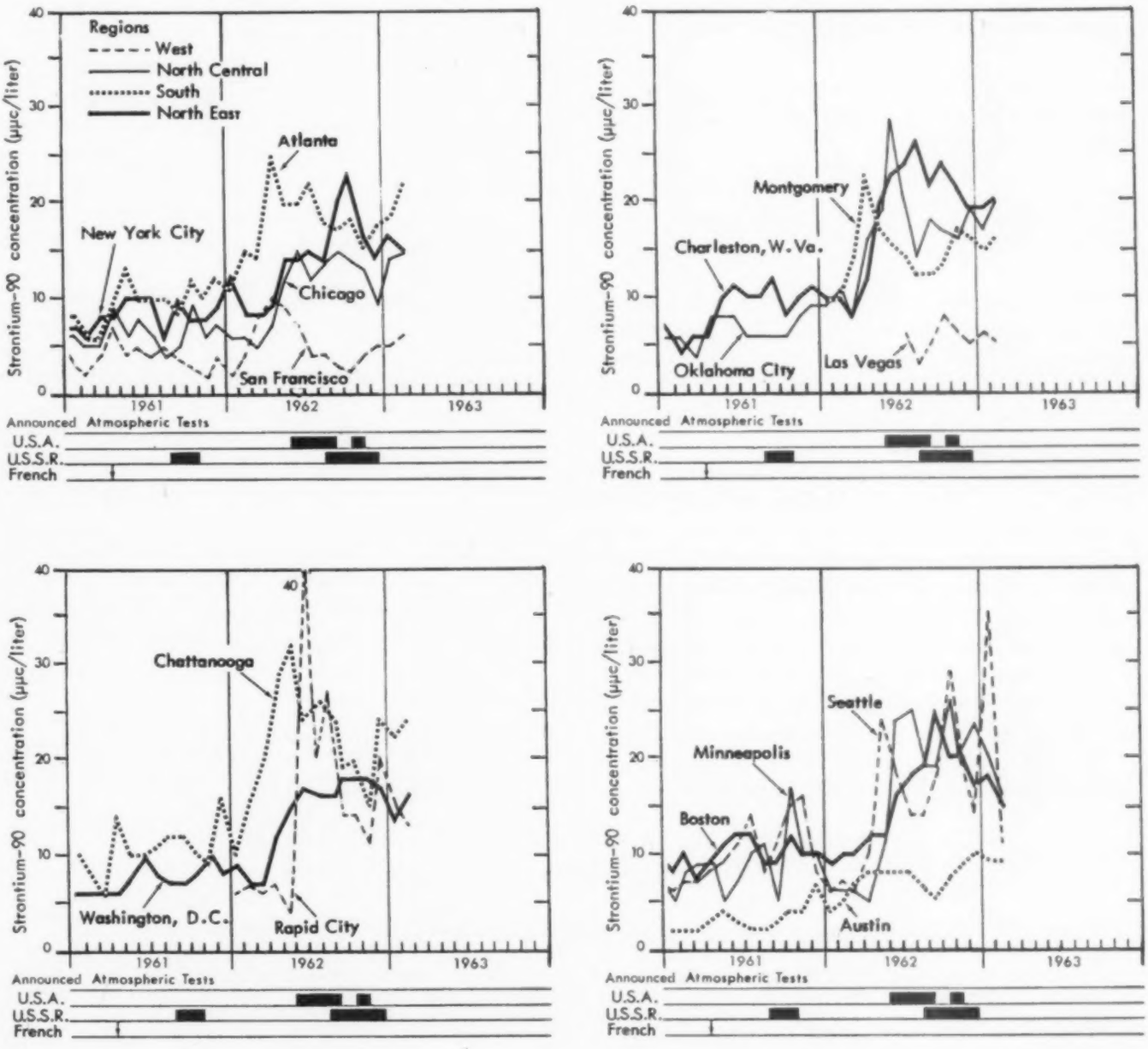

FIGURE 3.—STRONTIUM–90 CONCENTRATIONS IN PASTEURIZED MILK

Selected Monthly Strontium-90 Profiles

Continuing the practice of previous issues of *Radiological Health Data*, figure 3 presents the average monthly strontium-90 concentrations in pasteurized milk samples from 15 selected cities in the sampling program. Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions.

REFERENCE

(*1*) United States Department of Agriculture Statistical Reporting Service: *Weekly Weather and Crop Bulletin, Volumn L, Nos. 1–4*, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (February 1963), price per year $3.00, single copy price 10 cents.

INDIANA MILK NETWORK
February–March 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 4).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-lanthanum-140, strontium-89, and strontium-90. Analyses for the gamma emitters iodine-131, cesium-137, and barium-lanthanum-140 are conducted on a weekly basis except when iodine-131 results exceed 100 $\mu\mu$c/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses.

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-lanthanum-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

REFERENCE

(*1*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306–8 (September 1961).

TABLE 4.—RADIONUCLIDES IN INDIANA MILK, FEBRUARY–MARCH 1963

[Concentrations in $\mu\mu$c/liter]

Sampling location	Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-Lanthanum-140	
	February	March	February	March	February	March	February	March	February	March
Evansville	<10	80	14	18	<10	<10	40	45	<10	<10
Fort Wayne	<10	<10	18	16	<10	<10	55	55	<10	<10
Indianapolis	<10	10	16	19	<10	<10	50	50	<10	<10
Rochester	<10	<10	16	16	<10	<10	60	55	<10	<10
Seymour	<10	60	21	20	<10	<10	60	55	<10	<10
State average	<10	30	17	18	<10	<10	55	50	<10	<10

CANADIAN MILK NETWORK
January 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department had previously analyzed milk powders from November 1955 through December 1962, but liquid whole milk was only monitored for iodine-131 since April 1962.

With this change, it has been possible to choose milk sampling locations in the same areas as the air and precipitation stations (see figure 5). This permits the observation of a number of environmental variables which may affect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses may be found in the Department's publications (*1*, *2*). Table 5 presents the results of the measurements of strontium-89, strontium-90, and iodine-131 in Canadian liquid whole milk for January 1963. These data were taken from the monthly publication, "Data from Radiation Protection Programs," of the Radiation Protection Division of the Canadian Department of National Health and Welfare.

Because of technical difficulties, no cesium-137 results for January are available. The national average iodine-131 profile (figure 6) shows that

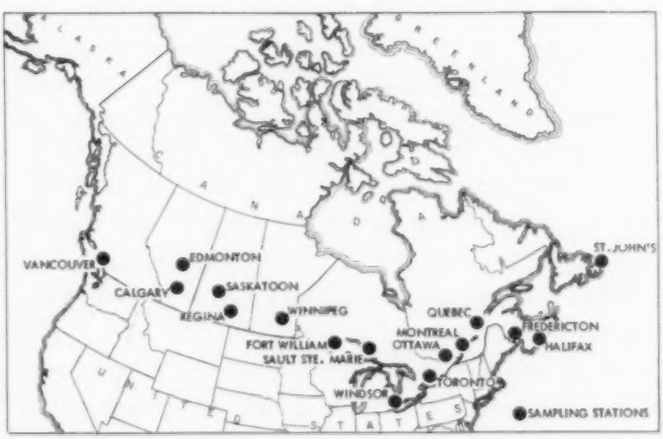

FIGURE 5.—CANADIAN MILK SAMPLING STATIONS

TABLE 5.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JANUARY 1963

Station	Calcium (g/liter)	Strontium -89 (μμc/liter)	Strontium -90 (μμc/liter)	Iodine -131 (μμc/liter)
Calgary	1.19	8	20.4	[a]5 (13)
Edmonton	1.08	17	16.6	[b] —
Fort William	1.21	0	25.8	—
Fredericton	1.13	11	32.6	—
Halifax	1.14	0	26.9	3 (12)
Montreal	1.11	6	14.7	—
Ottawa	1.18	6	12.7	2 (13)
Quebec	1.09	10	26.8	4 (13)
Regina	1.08	8	14.1	—
Saint John's	1.04	12	22.7	—
Saskatoon	1.14	12	13.1	4 (13)
Sault St. Marie	1.04	23	20.1	3 (12)
Toronto	1.06	5	12.3	—
Vancouver	1.14	14	19.7	2 (13)
Windsor	1.08	0	12.9	5 (13)
Winnipeg	0.98	9	16.4	2 (13)
Average	1.10	11	19.2	3

[a] Numbers in parentheses indicate the number of samples on which the monthly averages are based.
[b] A dash indicates no sample.

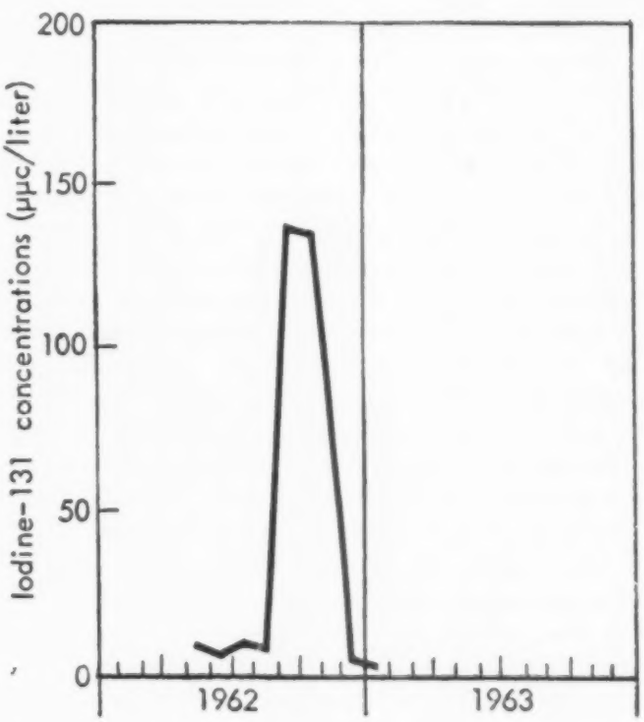

FIGURE 6.—AVERAGE IODINE-131 CONCENTRATIONS IN CANADIAN WHOLE MILK

iodine-131 concentrations remained low (3 μμc/liter) during January.

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the values of the concentration levels in a particular medium with the so-

called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*3*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period, such as one year, afford a better basis for comparison than do individual levels at any specific time.

REFERENCES

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report of the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, (RPD–1)*, (July 1958).

(*2*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, (RPD–5)*, Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).

(*3*) Recommendations of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine 131: April 1962–March 1963
Strontium–89 and Strontium–90: March 1962–February 1963

Division of Radiological Health, Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine-131, strontium-89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. The index values are estimated sums of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analysis, these 12-month index values are for the 12-month period beginning one month earlier than the iodine-131 values. The columns of monthly index values in each table are used to compute the net change as the 12-month index values are advanced by one month. The last column shows the latest 12-month index value. In addition, the second column in table 1 gives the March 1963 iodine-131 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly average for all weeks ending within a given month are averaged to obtain an average value for the month, and (c) the monthly radionuclide index value is determined by multiplying the monthly average by the number of days in the month. This number will be either 28 or 35, corresponding to the number of complete calendar weeks ending in a given month. Procedures, exemplified by (a) and (b) above, tend to minimize weighting the monthly average unequally by more frequent sampling when high values are found, particularly for a short-lived radionuclide such as iodine-131. The yearly index values are obtained by the following procedure. In column (A) are the twelve-month index values for the period indicated. In columns (B) and (C) are the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons it is desirable to use a standard quantity of milk in the development of index values for the different radionuclides. When one is concerned with strontium, 1 liter is a suitable

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

[$\mu\mu$c day/liter]

Station location		Mar. 1963 iodine-131 averages ($\mu\mu$c/liter)	Iodine-131 index values[a]			
			Mar. 1962-Feb. 1963 (A)	Mar. 1962 (B)	Feb. 24, 1963-Mar. 30, 1963 (C)	Apr. 1962-Mar. 1963 (D)
Ala:	Montgomery	<10	6,590	180	180	6,590
Alaska:	Palmer	<10	38,220	350	180	38,050
Ariz:	Phoenix	<10	4,270	350	180	4,100
Ark:	Little Rock	10	14,670	180	350	14,840
Calif:	Sacramento	<10	5,050	180	180	5,050
	San Francisco	<10	4,940	350	180	4,770
Colo:	Denver	20	5,720	180	700	6,240
Conn:	Hartford	<10	7,670	180	180	7,670
Del:	Wilmington	<10	11,870	180	180	11,870
D.C:	Washington	<10	8,440	180	180	8,440
Fla:	Tampa	<10	6,660	180	180	6,660
Ga:	Atlanta	<10	9,040	180	180	9,040
Hawaii:	Honolulu	<10	5,250	700	180	4,730
Idaho:	Idaho Falls	<10	9,240	350	180	9,070
Ill:	Chicago	<10	13,690	180	180	13,690
Ind:	Indianapolis	<10	12,010	180	180	12,010
Iowa:	Des Moines	<10	21,840	350	180	21,670
Kans:	Wichita	<10	21,740	180	180	21,740
Ky:	Louisville	<10	10,540	180	180	10,540
La:	New Orleans	10	9,600	180	350	9,770
Maine:	Portland	<10	8,160	180	180	8,160
Md:	Baltimore	<10	8,690	180	180	8,690
Mass:	Boston	<10	7,950	180	180	7,950
Mich:	Detroit	<10	12,820	180	180	12,820
	Grand Rapids	10	9,560	180	350	9,730
Minn:	Minneapolis	<10	16,170	700	180	15,650
Miss:	Jackson	10	9,530	180	350	9,700
Mo:	Kansas City	<10	30,240	350	180	30,070
	St. Louis	<10	12,530	350	180	12,360
Mont:	Helena	<10	14,630	700	180	14,110
Nebr:	Omaha	<10	19,390	350	180	19,220
Nev:	Las Vegas[b]	10	4,240	—[c]	350	4,590
N.H:	Manchester	<10	7,710	180	180	7,710
N.J:	Trenton	<10	7,990	180	180	7,990
N. Mex:	Albuquerque	<10	7,040	700	180	6,520
N.Y:	Buffalo	<10	8,720	180	180	8,720
	New York	<10	11,660	180	180	11,660
	Syracuse	10	9,980	180	350	10,150
N.C:	Charlotte	<10	3,370	180	180	3,370
N.Dak:	Minot	10	14,910	350	350	14,910
Ohio:	Cincinnati	<10	14,600	180	180	14,600
	Cleveland	<10	11,100	180	180	11,100
Okla:	Oklahoma City	<10	18,380	180	180	18,380
Ore:	Portland	<10	9,770	180	180	9,770
Pa:	Philadelphia	<10	10,820	180	180	10,820
	Pittsburgh	<10	14,810	180	180	14,810
P.R:	San Juan[d]	10	5,960	180	350	6,130
R.I:	Providence	<10	8,580	180	180	8,580
S.C:	Charleston	10	7,010	180	350	7,180
S. Dak:	Rapid City	<10	14,670	700	180	14,150
Tenn:	Chattanooga	<10	7,850	180	180	7,850
	Memphis	<10	10,050	180	180	10,050
Tex:	Austin	<10	11,040	180	180	11,040
	Dallas	<10	18,840	180	180	18,840
Utah:	Salt Lake City	10	31,920	350	350	31,920
Vt:	Burlington	<10	8,380	180	180	8,380
Va:	Norfolk	<10	6,410	180	180	6,410
Wash:	Seattle	<10	9,940	350	180	9,770
	Spokane	<10	21,910	700	180	21,390
W. Va:	Charleston	<10	6,970	180	180	6,970
Wis:	Milwaukee	<10	14,460	180	180	14,460
Wyo:	Laramie	<10	19,710	350	180	19,540

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index × milk consumption factor = 12-month I^{131} intake
($\mu\mu$c day/liter) (liter/day/person) ($\mu\mu$c/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 8 and 9 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. The sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK

Station location		Strontium-89 index values ($\mu\mu$c day/liter)[a]				Strontium-90 index values ($\mu\mu$c day/liter)[a]			
		Feb. 1962–Jan. 1963 (A)	Feb. 1962 (B)	Jan. 27, 1963–Feb. 23, 1963 (C)	Mar. 1962–Feb. 1963 (D)	Feb. 1962–Jan. 1963 (A)	Feb. 1962 (B)	Jan. 27, 1963–Feb. 23, 1963 (C)	Mar. 1962–Feb. 1963 (D)
Ala:	Montgomery	23,555	1,540	2,240	24,255	5,474	336	448	5,586
Alaska:	Palmer	19,095	140	420	19,375	3,808	168	280	3,920
Ariz:	Phoenix	6,460	420	560	6,600	1,176	84	84	1,176
Ark:	Little Rock	50,365	3,080	3,080	50,365	10,906	616	952	11,242
Calif:	Sacramento	7,055	140	280	7,195	1,393	84	112	1,421
	San Francisco	13,020	700	1,400	13,720	1,981	112	168	2,037
Colo:	Denver	10,310	280	280	10,310	3,731	112	280	3,899
Conn:	Hartford	8,070	70	140	8,140	3,927	280	336	3,983
Del:	Wilmington	13,195	70	70	13,195	4,977	308	504	5,173
D.C:	Washington	12,760	70	70	12,760	5,285	196	448	5,537
Fla:	Tampa	9,415	700	1,400	10,115	3,633	252	420	3,801
Ga:	Atlanta	30,800	4,200	3,080	29,680	6,608	420	616	6,804
Hawaii:	Honolulu	10,045	2,240	980	8,785	1,918	224	280	1,974
Idaho:	Idaho Falls	8,875	140	280	9,015	3,486	84	224	3,626
Ill:	Chicago	10,800	70	70	10,800	4,116	168	420	4,368
Ind:	Indianapolis	13,930	70	280	14,140	4,949	252	476	5,173
Iowa:	Des Moines	23,960	140	280	24,100	4,718	140	392	4,970
Kans:	Wichita	18,620	420	420	18,620	4,270	196	364	4,438
Ky:	Louisville	28,210	420	700	28,490	7,294	336	560	7,518
La:	New Orleans	58,170	10,220	7,560	55,510	11,046	868	1,008	11,186
Maine:	Portland	10,800	70	70	10,800	5,299	364	532	5,467
Md:	Baltimore	11,815	140	70	11,745	5,544	252	392	5,684
Mass:	Boston	11,360	70	140	11,430	5,992	280	420	6,132
Mich:	Detroit	9,855	70	70	9,855	4,242	168	504	4,578
	Grand Rapids	8,560	140	140	8,560	3,794	196	336	3,934
Minn:	Minneapolis	20,285	140	280	20,425	6,216	168	448	6,496
Miss:	Jackson	55,020	8,400	5,880	52,500	8,792	588	952	9,156
Mo:	Kansas City	30,940	420	560	31,080	5,404	224	420	5,600
	St. Louis	19,390	280	280	19,390	4,963	196	336	5,103
Mont:	Helena	16,590	140	420	16,870	4,487	112	364	4,739
Nebr:	Omaha	21,035	420	420	21,035	4,889	140	448	5,197
Nev:	Las Vegas[b]	5,040	[c]—	560	5,600	1,162	—	140	1,302
Nev:	Manchester	10,415	70	70	10,415	5,362	308	560	5,614
N.J:	Trenton	9,925	70	140	9,995	4,158	252	280	4,186
N. Mex:	Albuquerque	6,185	280	280	6,185	1,617	56	140	1,701
N.Y:	Buffalo	8,980	70	70	8,980	4,228	196	476	4,508
	New York	10,555	70	70	10,555	5,075	224	420	5,271
	Syracuse	9,555	70	140	9,625	4,228	224	280	4,284
N.C:	Charlotte	20,790	980	700	20,510	7,259	308	560	7,511
N. Dak:	Minot	16,655	70	280	16,865	7,294	224	616	7,686
Ohio:	Cincinnati	17,780	560	280	17,500	5,481	308	448	5,621
	Cleveland	10,730	70	70	10,730	4,438	224	392	4,606
Okla:	Oklahoma City	26,180	1,120	1,400	26,460	6,230	308	560	6,482
Ore:	Portland	30,485	420	980	31,045	5,026	196	252	5,082
Pa:	Philadelphia	10,415	70	70	10,415	4,781	252	616	5,145
	Pittsburgh	12,215	70	280	12,425	5,754	364	448	5,838
P.R:	San Juan[d]	24,745	3,080	4,340	26,005	3,395	112	308	3,591
R. I:	Providence	9,190	70	70	9,190	4,697	280	504	4,921
S.C:	Charleston	24,780	2,380	3,920	26,320	7,014	364	728	7,378
S. Dak:	Rapid City	20,215	420	560	20,355	5,740	196	364	5,908
Tenn:	Chattanooga	42,910	2,240	1,260	41,930	8,197	448	588	8,337
	Memphis	38,010	3,780	2,240	36,470	7,798	392	700	8,106
Tex:	Austin	11,655	700	980	11,935	2,702	140	252	2,814
	Dallas	30,275	1,400	2,380	31,255	5,593	336	560	5,817
Utah:	Salt Lake City	11,220	70	420	11,570	3,367	112	336	3,591
Vt:	Burlington	10,975	70	140	11,045	4,298	224	420	4,494
Va:	Norfolk	17,395	420	1,120	18,095	6,552	336	448	6,664
Wash:	Seattle	21,945	280	700	22,365	5,523	196	308	5,635
	Spokane	13,530	140	280	13,670	4,655	168	336	4,823
W. Va:	Charleston	21,070	280	280	21,070	6,853	280	560	7,133
Wis:	Milwaukee	8,455	70	280	8,665	3,136	168	336	3,304
Wyo:	Laramie	19,165	70	560	19,655	3,864	112	336	4,088

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual strontium-89 or strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average daily milk consumption for any selected group under consideration.

Example: 12-month index value × milk consumption factor = 12-month intake
($\mu\mu$c day/liter) (liter/day/person) ($\mu\mu$c/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 7 and 8 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine-131, the critical age group is the young infant group. Available information suggests that the average milk consumption of infants in the 6–18 month group is not more than 1 liter per day. Thus, the index value based on 1 liter of milk, though not actually an average intake value, is a useful index for estimating total intake.

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SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
December 1962

Division of Water Supply and Pollution Control, Public Health Service

Radioactivity levels in the surface waters of the United States have been included in the surveillance of the Public Health Service's National Water Quality Network since this nationwide sampling program was initiated in 1957. Beginning with the establishment of 50 sampling points, this network has been expanded as of March 1, 1963, to 125 stations (figure 1), which are operated jointly with State, Federal and local agencies and industry. The stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. At these stations, samples are taken weekly, monthly, or continuously, depending on the type of analysis to be performed and on the water quality. These samples

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, DECEMBER 1962

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS[1,2]

[Average concentrations in pc/liter]

Station	December 1962			
	Beta activity		Alpha activity	
	Dissolved	Total	Dissolved	Total
Animas River: Cedar Hill, N. Mex.	18	41	4	6
Apalachicola River: Chattahoochie, Fla.	32	40	0	1
Arkansas River: Coolidge, Kans.	97	135	38	42
Bear River: Preston, Idaho	32	34	2	2
Bighorn River: Hardin, Mont.	38	59	7	9
Sioux River: Sioux Falls, S. Dak.	38	55	8	10
Chattahoochie River:				
Atlanta Ga.	9	15	0	0
Columbus, Ga.	9	18	0	0
Lanett, Ala.	11	23	0	1
Clear Water River: Lewiston, Idaho	18	36	0	0
Clinch River: Clinton, Tenn.	13	17	1	1
Colorado River:				
Loma, Colo.	30	53	10	14
Page, Ariz.	42	90	10	21
Parker Dam, Calif-Ariz.	4	57	6	7
Columbia River:				
Northport, Wash.	17	24	1	1
Wenatchee, Wash.	7	10	0	0
Pasco, Wash.	434	466	0	0
McNary Dam, Ore.	284	320	1	1
Bonneville, Ore.	183	377	1	1
Clatskanie, Ore.	79	90	<1	<1
Connecticut River:				
Wilder, Vt.	15	25	0	<1
Northfield, Mass.	16	18	0	0
Enfield Dam, Conn.	18	26	0	<1
Cuyahoga River: Cleveland, Ohio	54	67	0	<1
Delaware River:				
Martins Creek, Pa.	15	19	0	0
Trenton, N. J.	20	35	1	1
Philadelphia, Pa.	15	33	0	1
Great Lakes:				
Duluth, Minn.	4	4	0	0
Sault Ste. Marie, Mich.	6	12	0	0
Milwaukee, Wis.	9	10	—	—
Gary, Ind.	2	3	0	0
Port Huron, Mich.	8	12	0	0
Detroit, Mich.	11	14	0	0
Green River: Dutch John, Utah	16	22	4	4
Illinois River:				
Peoria, Ill.	19	30	0	0
Grafton, Ill.	29	84	2	12
Kanawha River: Winfield Dam, W. Va.	9	21	0	0
Klamath River: Keno, Ore.	17	28	0	0
Little Miami River: Cincinnati, Ohio	46	57	1	1
Merrimack River: Lowell, Mass.	38	102	0	0
Mississippi River:				
St. Paul, Minn.	16	18	1	1
E. St. Louis, Ill.	15	19	3	3
Cape Girardeau, Mo.	24	45	2	2
W. Memphis, Ark.	18	27	0	1
New Orleans, La.	25	47	1	1
Vicksburg, Miss.	27	51	1	3
Missouri River:				
Williston, N. Dak.	34	76	1	1
Yankton, S. Dak.	21	27	2	2
Omaha, Nebr.	26	40	7	9
Kansas City, Kans.	23	38	6	8
St. Louis, Mo.	31	44	2	3
Missouri City, Mo.	34	50	6	8
Monongahela River: Pittsburgh, Pa.	11	13	0	0
North Platte River: Henry, Nebr.	54	64	30	30
Ohio River:				
E. Liverpool, Ohio	11	17	0	0
Addison, Ohio	27	38	0	<1
Huntington, W. Va.	13	16	0	0
Louisville, Ky.	12	34	0	2
Evansville, Ind.	20	29	0	0
Cairo, Ill.	14	19	1	7
Pend Oreille River: Albeni Falls Dam, Idaho	15	20	<1	<1
Platte River: Plattsmouth, Nebr.	37	79	7	9
Potomac River: Great Falls, Md.	19	31	0	0
Rainy River: International Fls, Minn.	24	28	1	1
Red River: Grand Forks, N. Dak.	25	25	0	0
Red River, South:				
Denison, Tex.	29	31	2	2
Index, Ark.	37	72	0	4
Bossier City, La.	39	239	1	6
Rio Grande River:				
El Paso, Tex.	41	49	1	1
Laredo, Tex.	42	62	5	5
Roanoke River: John H. Kerr Resr. & Dam, Va.	18	26	0	0
Sabine River: Ruliff, Tex.	38	70	1	1
Sacramento River: Greens Landing, Courtland, Calif.	8	75	0	9
San Joaquin River: Vernalis, Calif	12	19	1	2
San Juan River: Shiprock, N. Mex.	68	88	9	10
St. Lawrence River: Massena, N. Y.	17	23	1	1
Savannah River: Port Wentworth, Ga.	16	23	0	0
Shenandoah River: Berryville, Va.	14	23	1	1
Ship Creek: Anchorage, Alaska	6	10	0	0
Snake River:				
Ice Harbor Dam, Wash.	17	23	1	1
Wawawai, Wash.	18	23	2	2
Payette, Idaho	26	36	4	4
South Platte River: Julesburg, Colo.	68	96	36	38
Spokane River: Post Falls, Idaho	13	20	<1	<1
Susquehanna River: Conowingo, Md.	9	16	0	0
Tennessee River:				
Chattanooga, Tenn.	47	60	1	1
Bridgeport, Ala.	41	41	0	0
Pickwick Landing, Tenn.	36	43	0	0
Lenoir City, Tenn.	14	22	0	0
Verdigris River: Nowata, Okla.	49	69	<1	1
Wabash River: New Harmony, Ind	15	37	2	3
Willamette River: Portland, Ore.	12	29	0	<1
Yakima River: Richland, Wash.	7	10	1	1
Yellowstone River: Sidney, Mont.	33	39	4	4

[1] These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*7*).

[2] Dashes indicate data are not available.

are then analyzed for plankton population, organic chemicals, radioactivity, and chemical, biological, and physical quality (*1*, *2*).

Radioactivity associated with dissolved solids provides a rough measure of levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*3*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*4*, *5*).

For the first two years of the network's operations, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples.

Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analyses are done weekly.

If at any time activity significantly greater than normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least once every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*6*). Because strontium-90 analyses are done quarterly, the results will be published on this basis.

Table 1 presents the results of the alpha and beta analyses on raw surface water in the United States for December 1962. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*7*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station in December 1962.

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Radioactivity in Surface Waters of the United States
1957–1962

Leo Weaver, Alfred W. Hoadley, and Stanley Baker [1]

Levels of radioactivity in the surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Composed at first of 50 sampling points, the network included, by March 1, 1963, 125 stations (see figure 1) operated jointly with State, Federal and local agencies, and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically, and radiologically. The network can then provide data for evaluating sources of radioactivity which may affect all legitimate uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected.

The purpose of this article is to discuss Network measurements of radioactivity in surface waters, to report on levels of radioactivity in these surface waters, and to explore the meaning of certain data collected since 1957. Data assembled through the network are published in an annual compilation (*1*, *2*, *3*, *4*).

[1] Mr. Weaver is Chief, and Messers. Hoadley and Baker are staff members, Water Quality Section, Basic Data Branch, Division of Water Supply and Pollution Control, Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati 26, Ohio.

Radioactivity Measurements

One-liter grab samples are collected weekly by personnel of the participating agencies and shipped to the Public Health Service's Network Laboratory in Cincinnati, Ohio for analysis. Determinations of radioactivity in the suspended and dissolved solids are carried out on a frequency schedule based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in 1960. Then, beginning in January 1960, gross beta determinations were made on monthly composites of the weekly samples received from all stations except those below known poten-

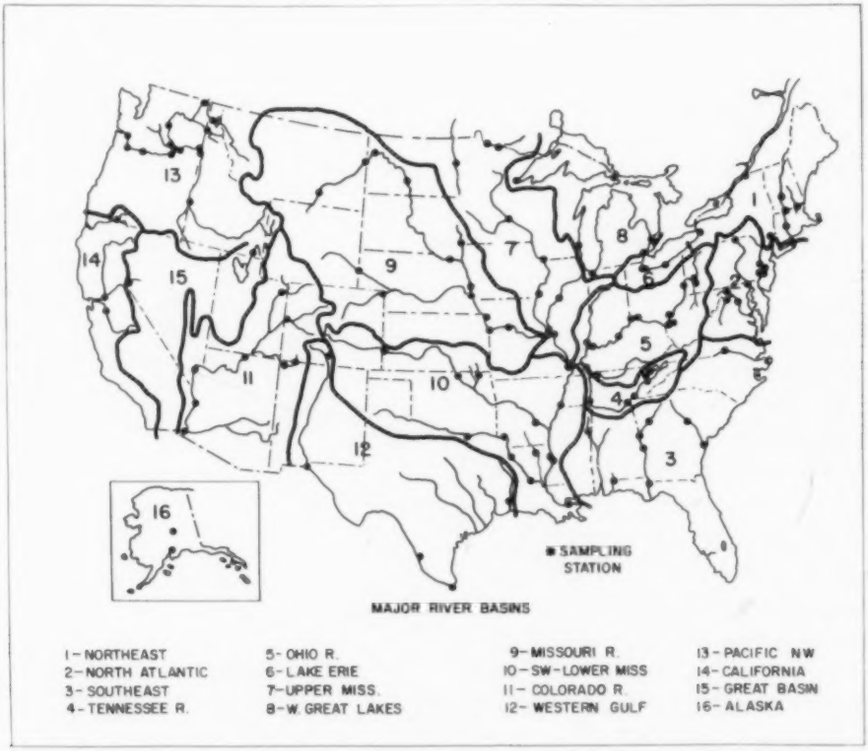

FIGURE 1.—MAJOR RIVER BASINS OF THE UNITED STATES SHOWING NATIONAL WATER QUALITY NETWORK STATIONS

tial sources of radioactive waste production and those from all newly established network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity were again initiated to permit rapid evaluation of fallout effects from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly, except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are received at the network laboratory within the week following collection. They are generally counted within two weeks after collection or within one week after compositing. The decay of activity is followed on samples that show unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. Results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*5*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns; planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred filter membrane) in an internal proportional counter.

Since the fourth quarter of 1958, strontium-90 analyses have been made on 3-month composite samples made from weekly aliquots. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the preceding reference. Tributylphosphate was used to extract ingrown yttrium-90 from the purified coprecipitated strontium-90. Since that time, a modification of a procedure described by Harley has been used (*6*). With this method, the yttrium-90 is coprecipitated with an yttrium carrier at a pH of 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate; and the latter is washed and counted in a low background, anticoincidence, end-window proportional counter.

Gross Beta Radioactivity

The pattern of gross beta radioactivity in the surface waters of the United States is shown in figure 2, which presents the quarterly median values of monthly station means of gross beta radioactivity of samples from the 47 stations that have been in operation since network sampling was started in 1957. This graph very clearly reflects the effects of fallout on surface waters. Activity levels ranged from 25 to 105 $\mu\mu$c/liter until the summer of 1959. At that time the levels dropped significantly, remaining for the most part below 10 $\mu\mu$c/liter from the fall of 1959 until the third quarter of 1961 when nuclear weapons testing in the atmosphere was resumed. A definite increase to over 60 $\mu\mu$c/liter in the first quarter of 1962 can be observed. The drop in the third and fourth quarters of 1962 probably can be attributed to a decrease in precipitation and runoff during this period of the year.

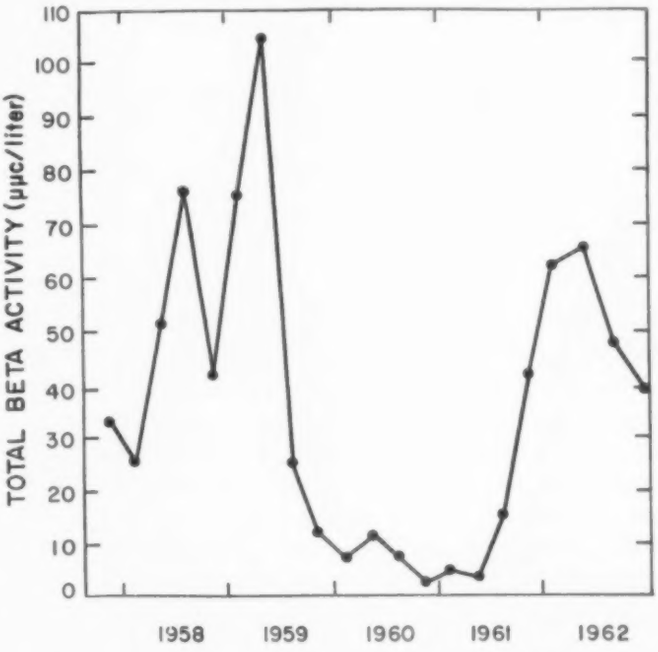

FIGURE 2.—QUARTERLY MEDIAN VALUES OF MONTHLY STATION MEANS OF GROSS BETA RADIOACTIVITY IN THE SURFACE WATERS OF THE UNITED STATES

A similar pattern can be observed in the curve representing the network mean values of quarterly composite strontium-90 analyses (figure 3). Strontium-90 levels dropped from 1.5 $\mu\mu$c/liter during the second quarter of 1959 to 0.6 $\mu\mu$c/liter during the first quarter of 1960. They remained at approximately this level until the resumption of

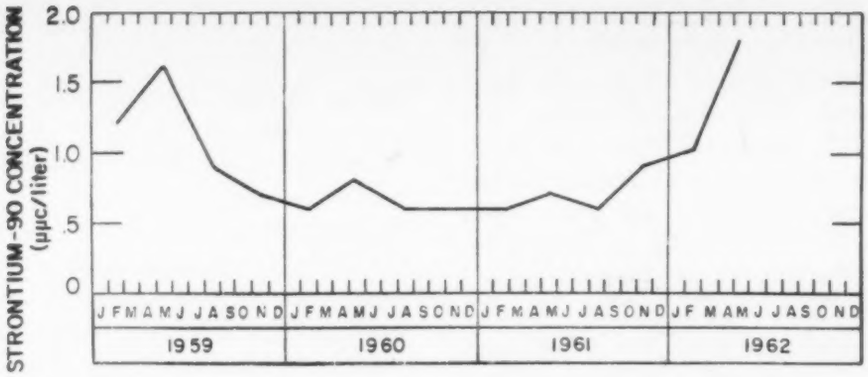

FIGURE 3.—NETWORK QUARTERLY MEAN STRONTIUM-90 IN SURFACE WATERS OF THE UNITED STATES

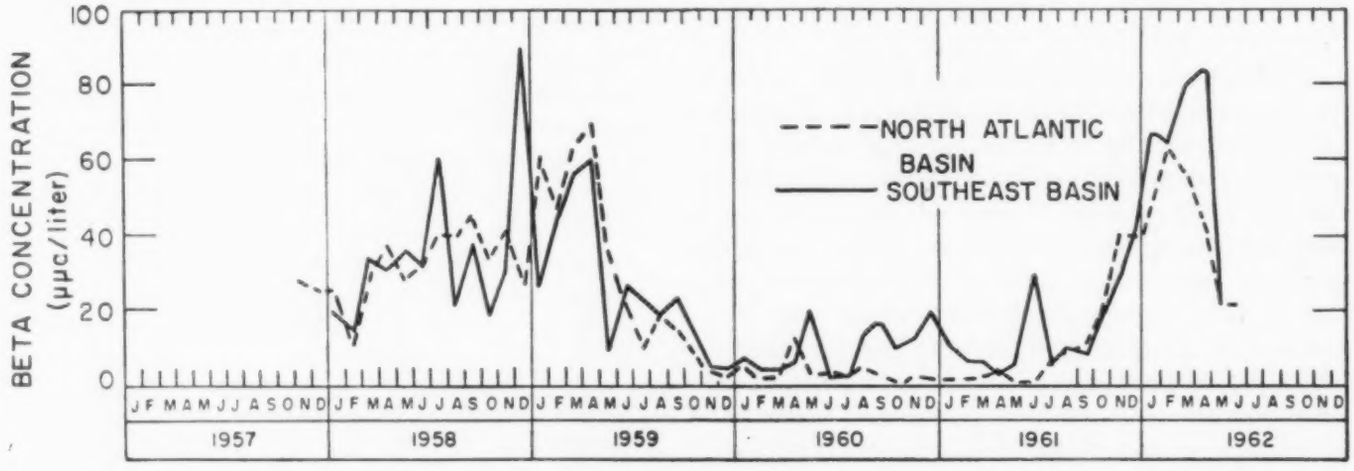

FIGURE 4.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE NORTH ATLANTIC AND SOUTHEAST BASINS

atmospheric nuclear weapons testing in 1961. The final quarter of 1961 reflected the beginning of an upward trend that reached 1.8 μμc/liter during the second quarter of 1962. These values for strontium-90 concentrations in river waters are low compared to the Public Health Service Drinking Water Standard of 10 μμc/liter (7). Further comparison of the value of 60 μμc/liter gross beta radioactivity to the Drinking Water Standard of 1,000 μμc/liter indicates that fallout does not contribute radioactivity approaching levels considered significant in drinking waters.

The above value of 1.8 μμc of strontium-90/liter of water is low in comparison to the Public Health Service Drinking Water Standards (7) which specify that water supplies should not exceed 10 μμc of strontium-90/liter. This low proportion of strontium-90 to the limiting value of 10 in the Standards permits comparison of the value of 60 μμc/liter of gross beta activity to the limiting value of 100 μμc/liter in the Standards.

Gross beta radioactivity profiles for six river basins are shown in figures 4–6. These curves are based on monthly means of weekly analyses or results of analyses of monthly composites. The monthly results of all stations in the respective basin are averaged to give a basin mean. Each of these curves reflects the national pattern shown in figure 2. In the North Atlantic and Southeast drainage basins, the levels of gross radioactivity (figure 4) are slightly below the national levels. Curves for the Ohio and Upper Mississippi River Basins (figure 5) are similar to those for the nation, but gross beta radioactivity levels responded more quickly to renewed weapons testing and the peaks are higher. The pattern for the Missouri and Lower Mississippi River Basins farther to the west (figure 6) also reflects fallout activity, but the peaks are higher than for the Ohio and Upper Mississippi River Basins. Meteorological and, to some degree, geological conditions undoubtedly influence the fallout pattern as reflected by radioactivity in the surface waters of the United States.

It can be seen in figure 7 that the pattern typical

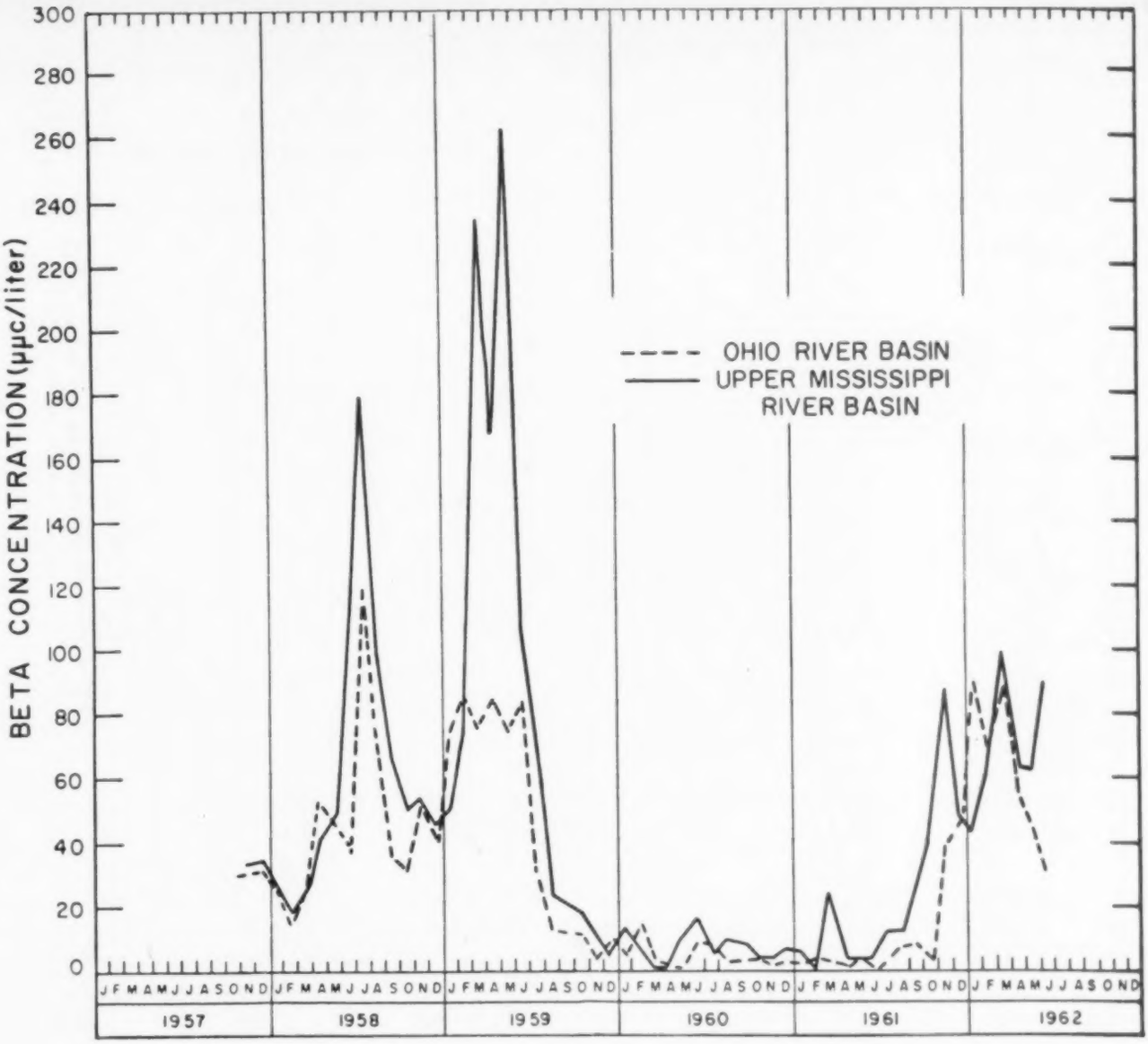

FIGURE 5.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE OHIO RIVER AND UPPER MISSISSIPPI RIVER BASINS

for the nation does not occur in the Columbia and Tennessee River Basins. In these basins, the effects of fallout are not evident. The higher levels of activity reflect effects of operations at the Hanford Works and Oak Ridge National Laboratory respectively, and the cyclic nature of the curves is a function of stream flow.

The relation of stream flow to radioactivity in the Columbia River at Pasco, Washington, is explored in figures 8 and 9. Figure 8 is plotted from monthly means of weekly samples for both stream flow and gross beta radioactivity taken on the same day and it is apparent that lower radioactivity levels are associated with the dilution provided by high flow. The quantitative aspect of this relationship is indicated in figure 9. Here stream flow plotted against the gross beta radioactivity concentration on a log-log scale strongly suggests a straight line relationship, as would be expected. The slope of this line is about -0.68. The deviation of the slope from negative unity would seem to indicate other effects of a systematic nature. The inverse relationship of radioactivity to stream flow in the Columbia River at Pasco is not a general one, however.

Quarterly mean stream flow and gross beta radioactivity for the Rio Grande at Laredo, Texas, are plotted in figure 10. Here the high radioactivity levels are associated with high stream flows. This relationship suggests that radioactive materials

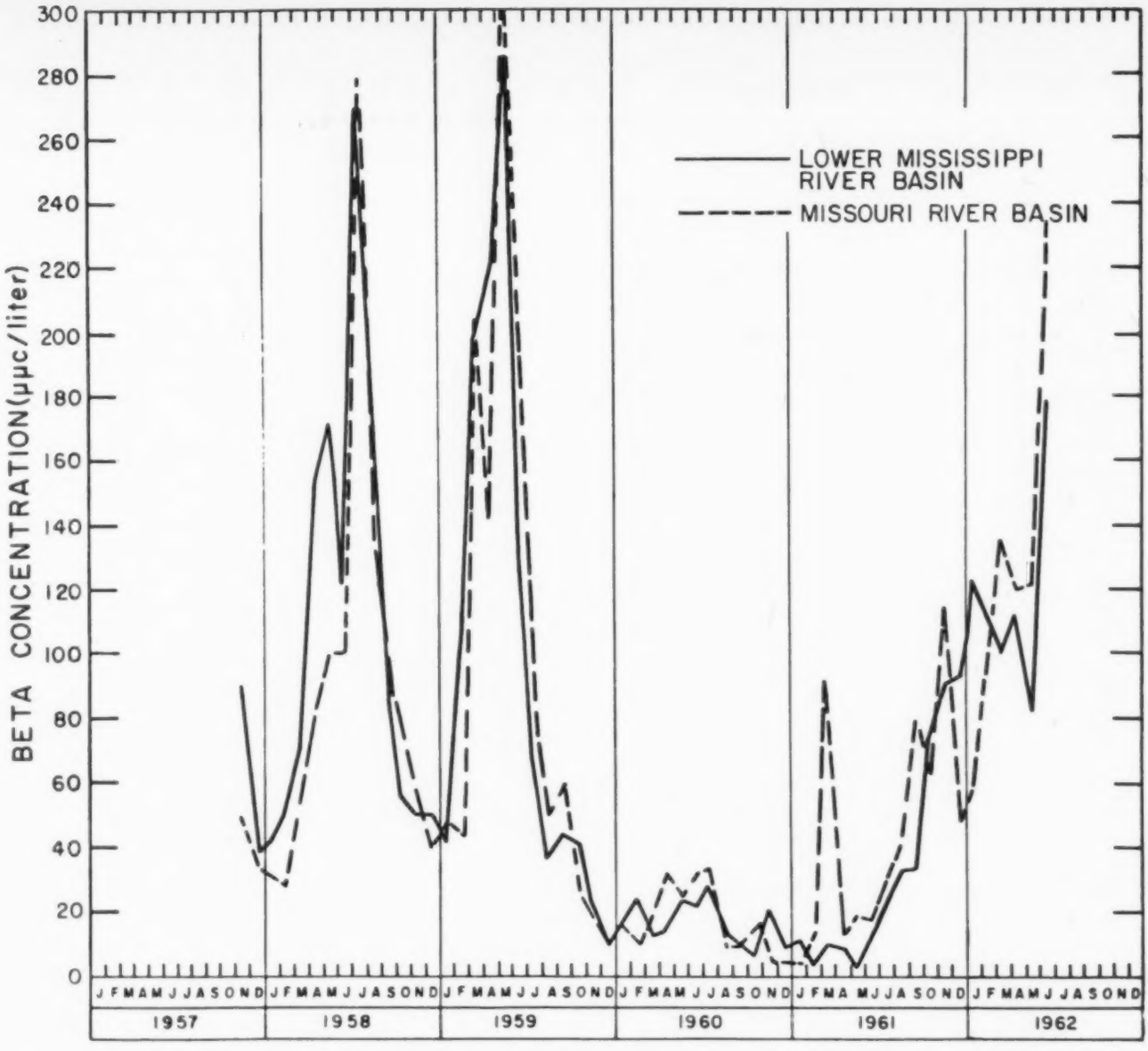

FIGURE 6.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE MISSOURI RIVER AND LOWER MISSISSIPPI RIVER BASINS

that occur naturally or originate from fallout are washed into the stream by runoff from the land during periods of rain. The many variables that might be expected to influence such a system make direct correlation of stream flow with radioactivity levels difficult. However, by an examination of the slopes of flow data and radioactivity, and an appropriate test of the sizes of these slopes, it can be shown that it is 95 percent certain that a nonrandom, or direct, relationship exists between stream flow and gross beta radioactivity concentrations in this stream. It is interesting to note that radioactivity in the Columbia River is largely in dissolved form, whereas that associated primarily with runoff, as in the Rio Grande, is found in both the suspended and dissolved matter.

Figures 11–13 are presented to show the effects of a large impoundment on the radioactivity load in a stream. The settling effects on suspended gross beta and suspended gross alpha radioactivity in Lake Mead on the Colorado River are shown in figures 11 and 13, respectively. The levels at Page, Arizona, above Lake Mead are considerably higher than those at Boulder City, Nevada, below Lake Mead, where the levels are nearly zero. Therefore, the suspended matter has evidently settled in Lake Mead. From National Water Quality Network data, it has been estimated that the difference between the alpha radioactivity passing Page and that leaving Lake Mead at Boulder City during the 1959–60 water year was over 457 curies. Figure 12, on the other hand,

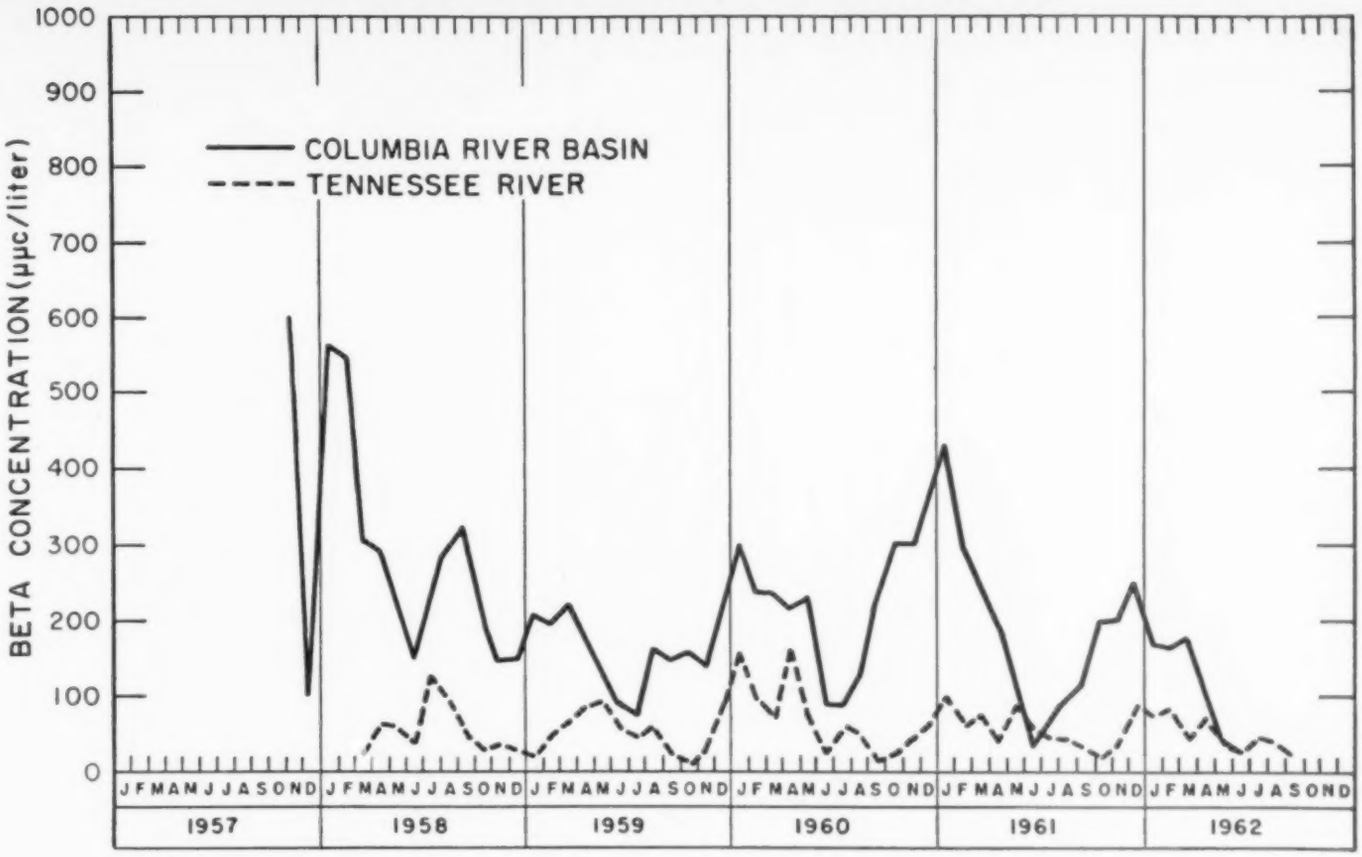

FIGURE 7.—BASIN MEANS OF GROSS BETA RADIOACTIVITY IN THE COLUMBIA RIVER BASIN AND TENNESSEE RIVER

presents data for the Page and Boulder City sampling points which show a pattern of dissolved gross beta radioactivity very similar to what would be expected from fallout.

Gross Alpha Radioactivity

Gross alpha radioactivity, since it is not an appreciable part of fallout debris, does not generally fluctuate in surface waters as does gross beta radioactivity. The waters of the United States can thus be characterized in a general way with respect to gross alpha radioactivity content. Figure 14 presents such a characterization. This map has been prepared on the basis of mean gross alpha activities at each sampling station during its period of operation. The lines delineating concentration zones were located by interpolation between values and by outlining river basins when interpolation was not deemed suitable. (Cases of high alpha activity occurred at certain stations in low activity areas and vice-versa.) In general, zones of less than 1 μμc/liter may be oberved in the East and Northwest. The period of record for Alaska is less than one year, but the data available indicate mean values of less than 1 μμc/liter. Streams arising in the Rocky Mountians show alpha activity averaging greater than 20 μμc/liter. Values of 10 to 20 μμc/liter are found in the Upper Colorado River Basin and in the Yellowstone, Missouri, and Arkansas River, values for the latter three undoubtedly resulting from dilution of the higher activity concentration flowing from the upper reaches of these streams. All other streams sampled through the network have activities averaging from 1 to 10 μμc/liter.

In view of persistent, high gross alpha activities, particularly in the Rocky Mountain areas, studies are being conducted to determine the occurrence of radium in the regions of high activity. More complete future identification is planned for the isotopes responsible for this alpha activity at Network Stations.

Relatively high alpha activities observed at the Yellowstone River sampling point appear to originate to a large extent in the Bighorn River. Samples from the Bighorn River frequently contain high activity associated with high suspended

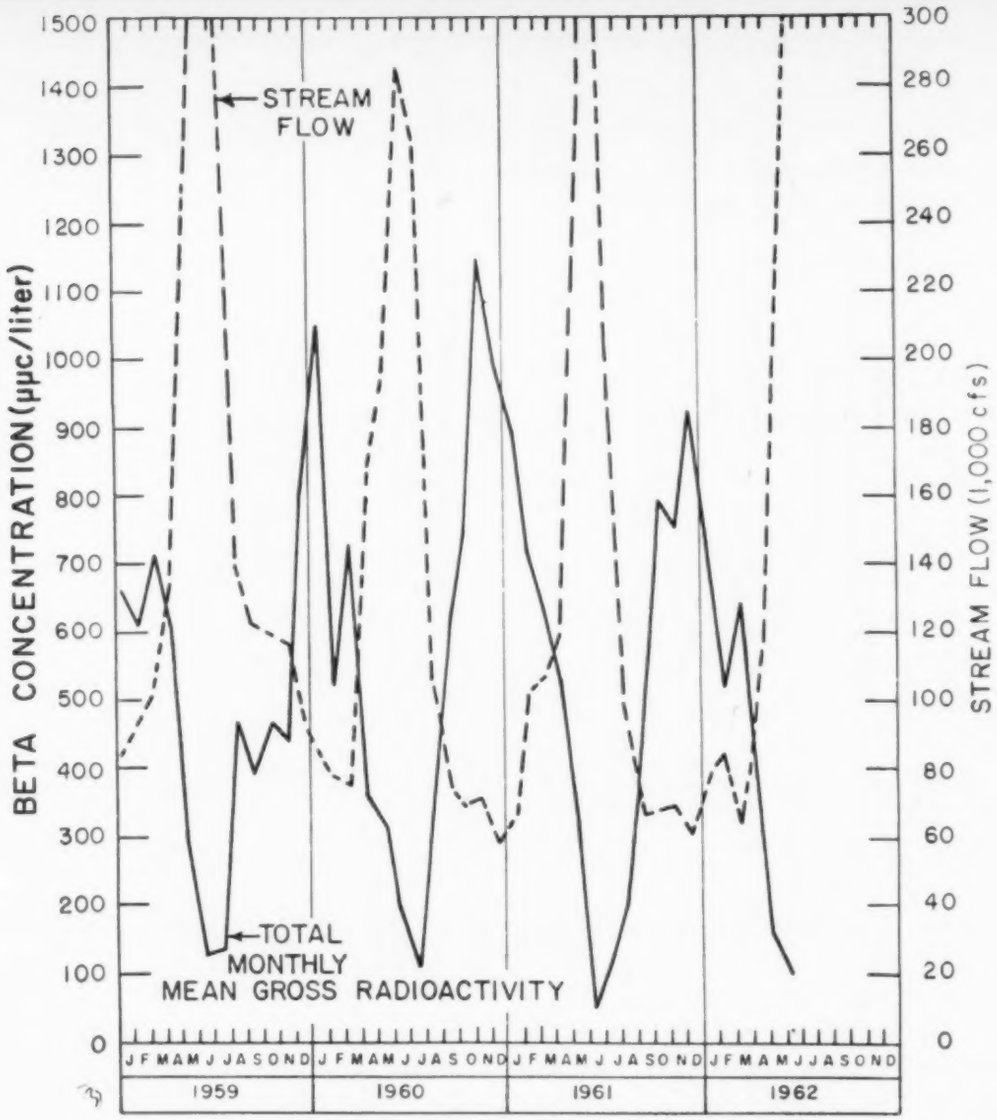

FIGURE 8.—GROSS BETA RADIO ACTIVITY AND STREAM FLOW IN THE COLUMBIA RIVER AT PASCO, WASHINGTON

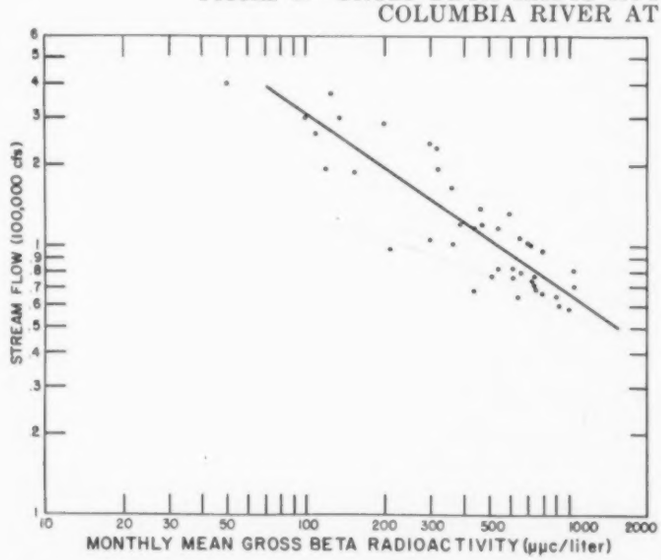

FIGURE 9.—STREAM FLOW VS. GROSS BETA RADIOACTIVITY IN THE COLUMBIA RIVER AT PASCO, WASHINGTON

solids. The North and South Platte and Arkansas Rivers, on the other hand, have higher activity in dissolved than in suspended matter (figure 15). In the Animas and San Juan Rivers, and particularly in the Colorado River at Page, Arizona, the alpha radioactivity is associated more with the suspended solids (figure 16). These are, at least in part, the result of uranium mining operations.

Conclusions

The data collected through the National Water Quality Network provides background information by which the behavior of radioactivity in surface waters can be better understood, and from which unusual situations can be identified and trends defined. Although weapons testing

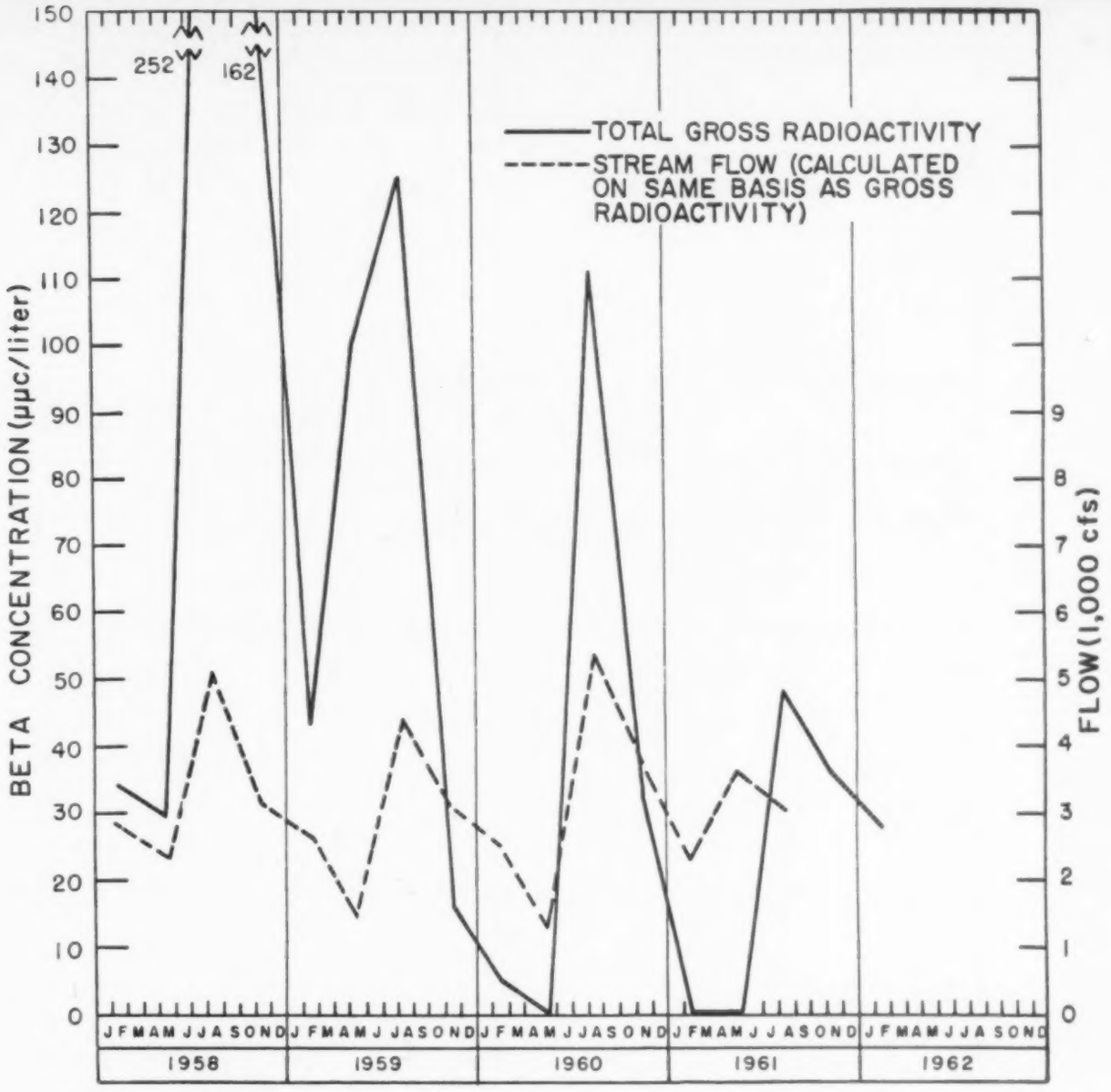

FIGURE 10.—QUARTERLY MEAN GROSS BETA RADIOACTIVITY AND STREAM FLOW IN THE RIO GRANDE AT LAREDO, TEXAS

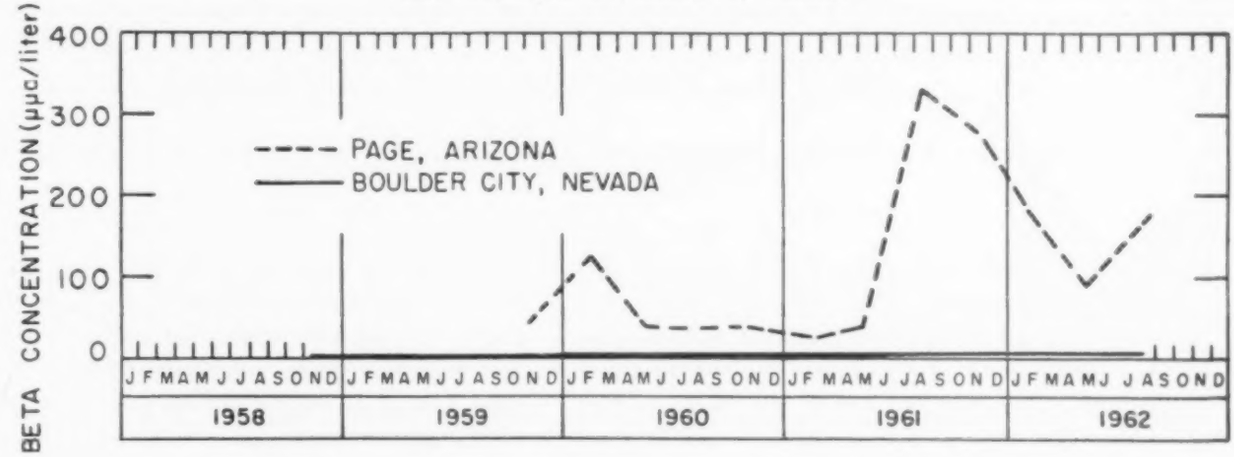

FIGURE 11.—SUSPENDED GROSS BETA RADIOACTIVITY IN THE COLORADO RIVER AT PAGE, ARIZONA, AND BOULDER CITY, NEVADA

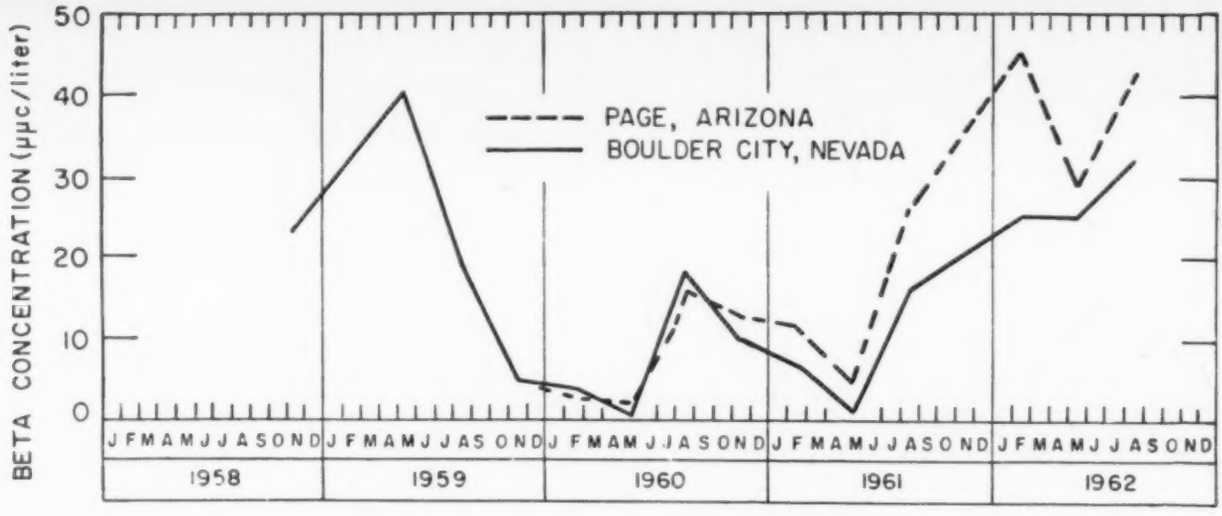

FIGURE 12.—DISSOLVED GROSS BETA RADIOACTIVITY IN THE COLORADO RIVER AT PAGE, ARIZONA, AND BOULDER CITY, NEVADA

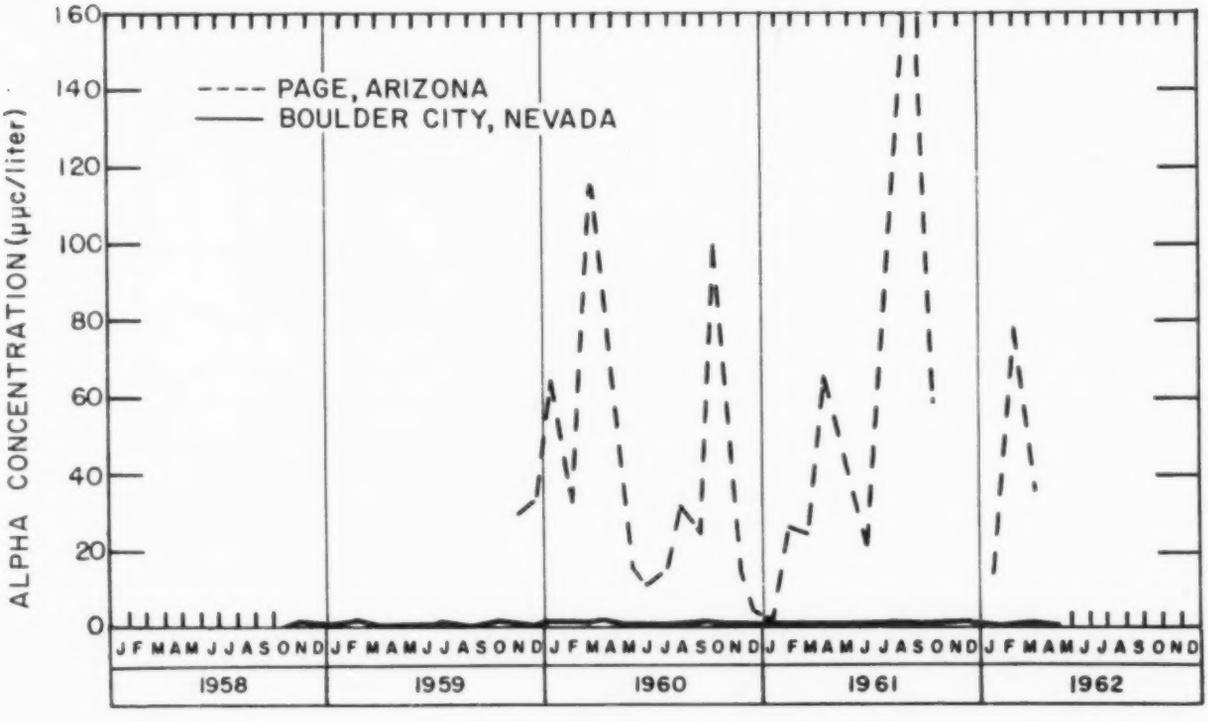

FIGURE 13.—SUSPENDED GROSS ALPHA RADIOACTIVITY IN THE COLORADO RIVER AT PAGE, ARIZONA, AND BOULDER CITY, NEVADA

recognizably affects our water, fallout has not contributed radioactivity even approaching levels considered of significance in drinking waters. The Public Health Service Drinking Water Standards (7) include recommended limits of 1,000 μμc/liter of gross beta radioactivity and 10 μμc/liter of strontium-90 in drinking water. Comparison of levels appearing in figures 2 through 6 to these limits shows that these levels were not reached during the period of October 1957 to December 1962. The understanding of fallout patterns and the behavior of radioactivity from sources other than fallout is important to the interpretation of observations made on a stream. The National Water Quality Network is a means for providing this understanding on a national basis.

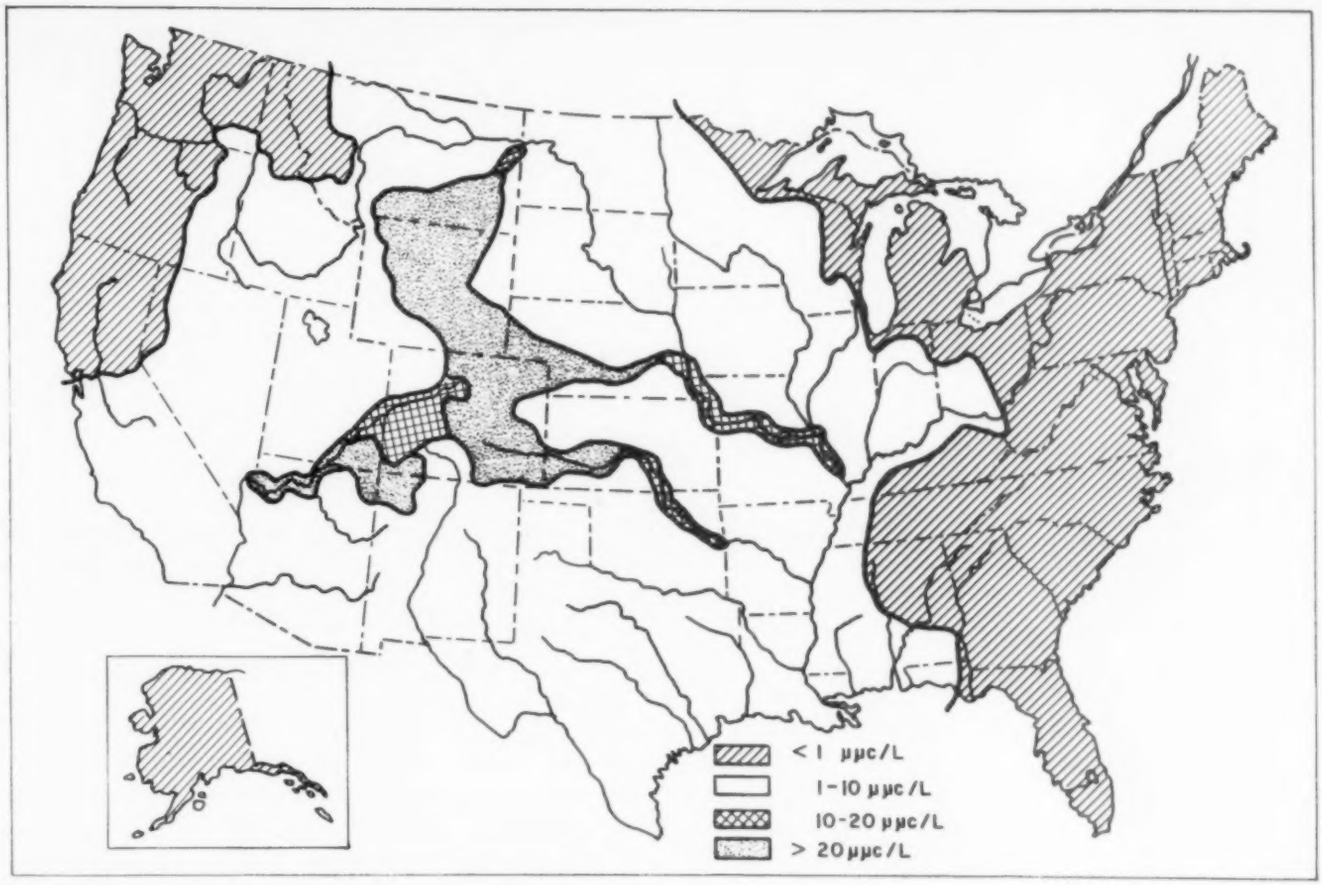

FIGURE 14.—MEAN GROSS ALPHA RADIOACTIVITY LEVELS IN THE UNITED STATES, 1957–1962

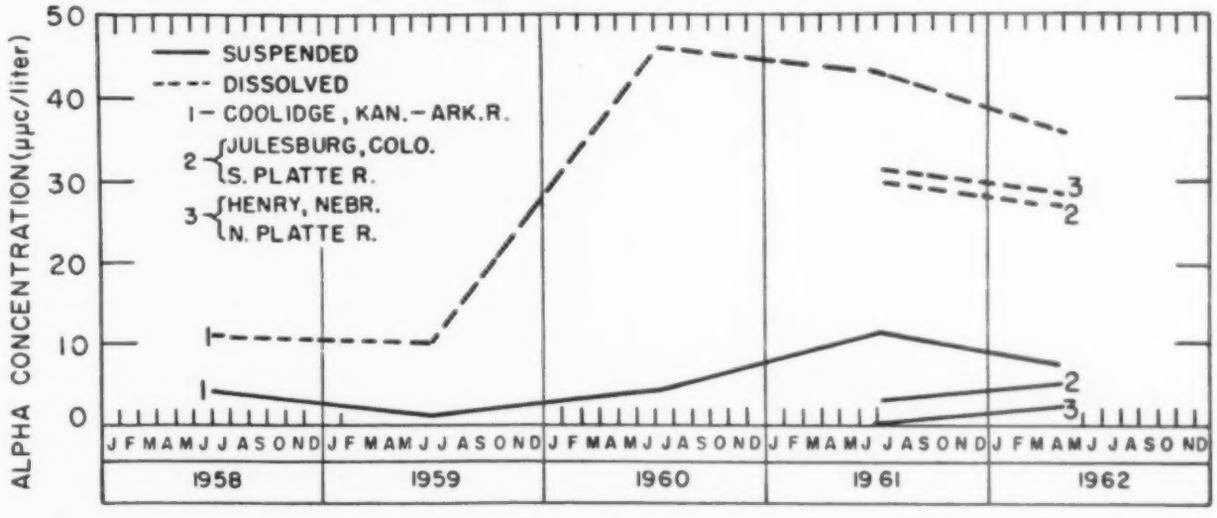

FIGURE 15.—YEARLY MEAN GROSS ALPHA RADIOACTIVITY LEVELS IN THE NORTH PLATTE, SOUTH PLATTE AND ARKANSAS RIVERS

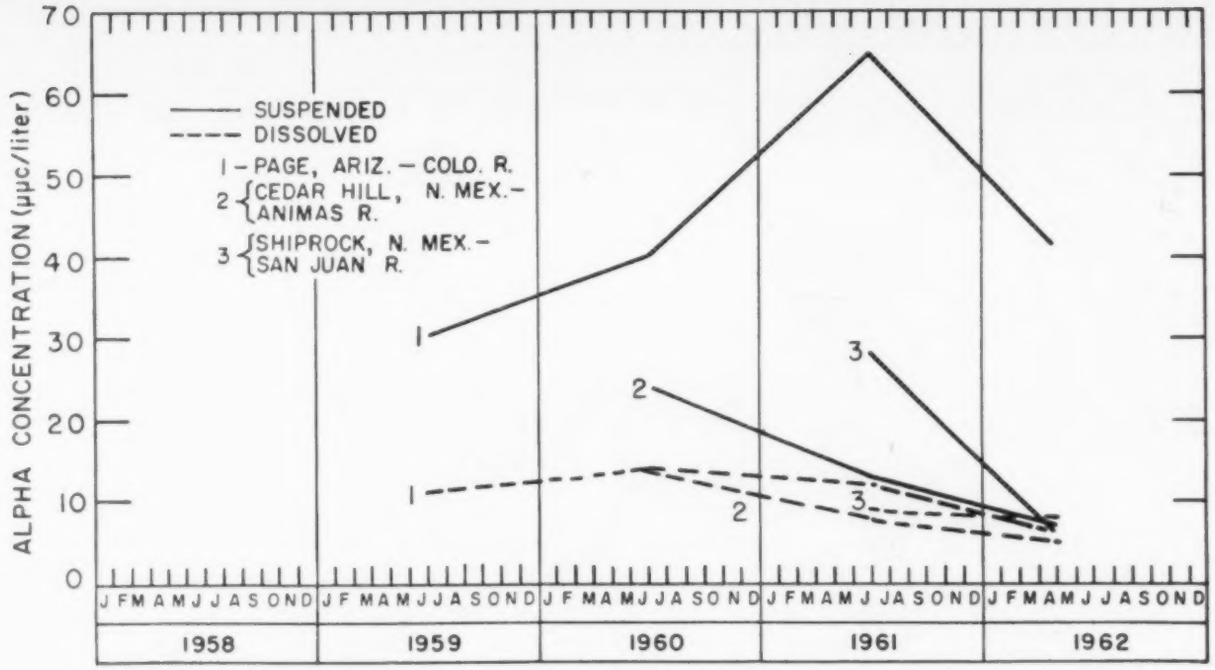

FIGURE 16.—YEARLY MEAN GROSS ALPHA RADIOACTIVITY LEVELS IN THE ANIMAS, SAN JUAN AND COLORADO RIVERS

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(2) Ibid., 1959 Edition.

(3) Ibid., 1960 Edition.

(4) Ibid., 1961 Edition.

(5) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(6) Harley, J. H.: *Radiochemical Determination of Strontium-90, Health and Safety Laboratory Manual of Standard Procedures*, Radiochemistry and Environmental Studies Division, U.S. Atomic Energy Commission, New Operations Office (August 1962 revision).

(7) Federal Register Rules and Regulations: *Title 42—Public Health Chapter 1— Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27:* 2154–5, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (March 6, 1962).

SECTION V.—OTHER DATA

Radionuclides in the Northwestern Alaska Food Chain, 1959–1961—A Review[1]

Robert P. Chandler and Samuel Wieder [2]

Among the important findings of an extensive program of environmental studies made in conjunction with the U.S. Atomic Energy Commission's proposed Project Chariot at the mouth of Ogotoruk Creek in Northwestern Alaska are those relating to radionuclides in the indigenous food chain (*1*, *2*). These radionuclide data are included in this review, together with a summary of cesium-137 body burden determinations obtained by the AEC from more than 600 inhabitants of certain coastal and inland villages in the general area. Supplementing these data are values for the strontium-90 content of Eskimo bone and urine samples reported by Schulert (*3*).

The ecological system for this area of Alaska involves man at the top of the food pyramid with fish, marine mammals, caribou and imported foods contributing the major part of the food supply, the amount of each depending on geographic location. Lichens, a fungal-algal variety of indigenous vegetation, and sedges constitute important sources of forage for the caribou. Studies of radionuclides in this food chain have had two general objectives: (1) to furnish data from which it might be possible to predict any effects from proposed controlled nuclear detonations, and (2) to estimate exposures attributable to fission product fallout. The proposed detonations were designed to excavate a basin and channel near Cape Thompson adjacent to the mouth of the Ogotoruk Creek. The channel would lead to the Chukchi Sea off the Northwestern Alaskan coast (see figure 1). This review is concerned primarily with the second of these objectives.

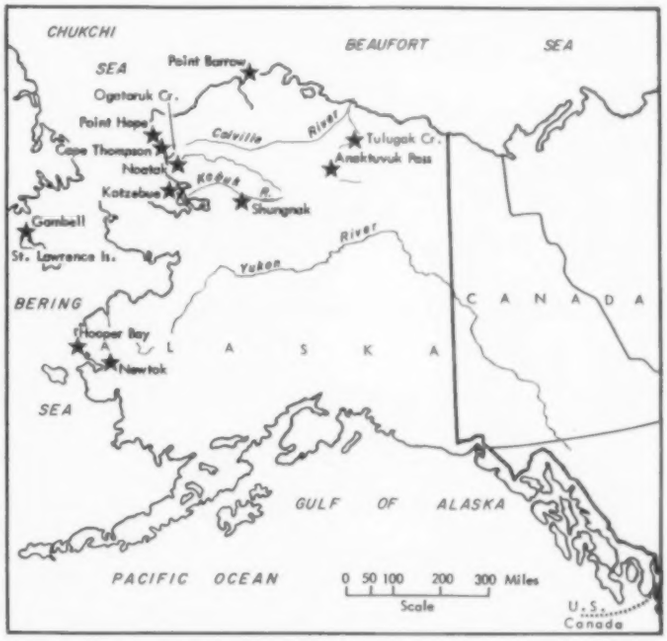

FIGURE 1.—INDIGENOUS FOOD CHAIN SAMPLING LOCATIONS IN NORTHWESTERN ALASKA

[1] Abstracted from various sources (see references).

[2] Mr. Chandler is Technical Editor, and Mr. Wieder is Public Health Analyst, Radiological Health Data and Reports Staff, Division of Radiological Health, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

Vegetation

Levels of radionuclides from fallout in five plant species (1960) are shown in table 1. Samples of these plants, collected in 1960 and analyzed for Mn^{54}, Zn^{65}, Sr^{90}, $Zr^{95} - Nb^{95}$, $Ru^{106} - Rh^{106}$, Cs^{137} and $Ce^{144} - Pr^{144}$, showed that the radionuclide contents of lichens, mosses and sedges were higher than those of willows and lupines.

Two of the factors which may account for differences in radionuclide concentrations in plants are age of aboveground plant parts and habitat. The time of exposure to fallout increases with increased age of the aerial parts of plants (*2*). Also, another study has shown that the accumulation of fallout debris is increased in plants growing in shallow water or saturated soils rather than in well-drained soil (*4*).

The longevity of lichens and mosses appears to be a factor accounting for their higher radionuclide concentrations as compared to annual varieties of vegetation. As the sedges *Carex* and *Eriophorum* grow in marshy places, this factor may explain in part their ability to accumulate fallout debris.

Table 2 shows the levels of gamma-emitting radionuclides in the sedge *Carex* sampled during the summers of 1959, 1960, and 1961. The 1961 samples were collected in the vicinity of Ogotoruk Creek before the resumption of atmospheric nuclear weapons testing in that year. Hence, the radionuclide levels may be attributed to fallout from weapons tests which took place prior to November 1958. The decrease of radionuclide levels in *Carex* during these years is explained as a function both of the half-lives of the radionuclides involved and of the proportions of plant tissues of different ages in the samples (*2*). The greater amounts of cesium-137 in 1961 than in 1959 samples are partly attributed to the fact that cesium-137 has a physical half-life of 30 years, and it accumulates on the top layer of the soil and is available for translocation by wind action. The physical half-life of zirconium-95 (65 days) and

TABLE 1.—FALLOUT RADIONUCLIDES IN VEGETATION AT OGOTORUK CREEK, 1960*

[Average concentrations in pc/gram dry weight]

Plant	Mn^{54}	Zn^{65}	Sr^{90}	Zr^{95}–Nb^{95}	Ru^{106}–Rh^{106}	Cs^{137}	Ce^{144}–Pr^{144}
Lichens	1.4	1.4	2.0	3.4	7.4	26	93
Moss							
Sphagnum species	1.9	1.7	3.0	0.88	17	18	134
Sedges							
Carex aquatilus	1.2	1.1	3.5	0	11	6.6	46
Eriophorum species	0.53	0.32	1.8	0.17	5.9	7.0	38
Willow							
Salix alexensis	0.31	0.17	1.2	0	3.4	3.2	22
Lupine							
Lupinus arcticus	0.40	0.15	1.1	0	3.9	2.4	14

* Abstracted from table 35 on page 144 of reference (*2*).

TABLE 2.—GAMMA-EMITTING RADIONUCLIDES IN THE SEDGE *CAREX* IN THE VICINITY OF OGOTORUK CREEK, 1959–1961*

[Concentrations in pc/gram dry weight]

Sampling date	Number of samples	Mn^{54}	Zn^{65}	Zr^{95}	Ru^{106}	Cs^{137}	Ce^{144}
August 6, 1959	9	9.1 ± 1.6†	1.0 ± 2.8	80 ± 7	16 ± 1.7	5.3 ± 1.0	240 ± 23
July 16, 1960	3	1.7 ± 0.59	1.7 ± 0.33		15 ± 0.65	8.4 ± 0.28	66 ± 23
July 31, 1961	10	0.7 ± 0.11	0.9 ± 0.15		8.1 ± 0.42	8.7 ± 0.75	28 ± 3.8

* Table 36 on page 146 of reference (*2*).

† Denotes average ± standard error.

the half-life of its radioactive daughter niobium-95 (35 days) account for the absence of these radionuclide values in the 1960 and 1961 samples reported in table 2 and for the low values reported in table 1.

Fish and Marine Mammals

Strontium-90 values in marine and fresh-water fish and in marine mammals are shown in table 3. The bulk of the samples was collected in 1959. In general, marine mammals had lower strontium-90 levels than either marine or fresh-water fish. Among the marine mammals, two samples of walrus (meat and backbone) showed the highest strontium-90 levels.

Caribou

The levels of strontium-90 and cesium-137 were generally much higher in caribou than in any of the other Alaskan dietary components sampled (*2*). These higher levels may be explained by the caribou's eating habits. Caribou browse on an assortment of vegetation, including plants that have been exposed to fallout for some time. Table 4 shows the percentage composition of caribou diets estimated from the examinations of individual rumen contents of caribou from Noatak, Colville, and Cape Thopmson in 1961. Inspection of this table indicates that lichens constitute a significant part of the diet of caribou in this area, especially in fall and winter.

Although different time periods are involved in tables 3, 5, and 6, data on strontium-90 concentrations in indigenous foods may be roughly compared. Generally, strontium-90 concentrations in caribou have shown consistently higher levels than have other indigenous foods. There was no pronounced seasonal trend for the levels of strontium-90 in caribou flesh. Whether there was any significant difference in strontium-90 levels in 1960 and early 1961 as compared to late 1961 due to the resumption of nuclear weapons testing cannot be discerned from the limited data available.

Cesium-137 concentrations in the flesh of caribou from the Colville and Cape Thompson regions during 1960–1961 are shown in table 7. A seasonal pattern of cesium-137 levels is apparent in caribou from the Colville region. The highest values occur during the winter, when plant parts that had been exposed to fallout for some time were the major source of caribou diets. The resumption of atmospheric nuclear weapons testing appeared to have contributed to the higher levels observed in November and December 1961.

Dietary Habits of Alaskan Eskimos and Indians

The food intake of residents of various geographic areas of Alaska was reported by Scott and Heller of the Arctic Health Research Center.

TABLE 3.—STRONTIUM-90 IN NATIVE ALASKAN FOODS[a]

Type of food	Location	Collection date	Strontium-90 content		
			pc/kg wet weight	pc/g ash	pc/g Ca
Marine fish					
Dried flounder and herring	Newtok	October 1959	50	0.7	2.7
Cod	Kotzebue	October 1959	163	3.0	7.9
Tom cods	Point Hope	December 1959	1.6	0.02	0.1
Needlefish	Hooper Bay	October 1959	272	3.3	7.6
Fresh-water fish					
Whitefish	Kobuk River	October 1959	70	1.0	16
Whitefish	Kobuk River	Spring 1960	[c]52	0.9	3.5
Whitefish	Kobuk River	Spring 1960	[c]635	11	33
Whitefish	Kobuk River	Spring 1960	[c]1,080	19	62
Marine mammals					
Beluga meat	Kotzebue	Fall 1959	12	0.4	142
Beluga meat	Kotzebue	October 1959	0.2	0.05	8.8
Beluga muktuk[b]	Kotzebue	October 1959		0.3	12
Seal backbone	Point Hope	Fall 1959	3.8	0.03	0.1
Walrus backbone	St. Lawrence	Spring 1959	146	0.3	0.8
Walrus meat	St. Lawrence	Spring 1959	81	4.2	360
Walrus meat	Gambell	December 1960		0.3	25
Whale meat	Point Hope	October 1959	<0.02	<0.03	<2.4
Whale rib (bowhead)	St. Lawrence	May 1959	<29	<0.05	<0.1
Land animals					
Polar bear meat	Point Hope	Fall 1959	<0.3	<0.03	<2.8

[a] Abstracted and derived from values in table 2, reference (*3*).
[b] Muktuk is the portion of whale skin found directly under the epidermis.
[c] Approximate values, since accurate wet weights were not obtained for these samples.

TABLE 4.—GROSS PERCENTAGE COMPOSITION OF INDIVIDUAL CARIBOU RUMEN CONTENTS, 1961[a]

Month	Location	Number sampled	Sedge and grass	Forbs[b]	Willow	Lichen	Moss	Miscellaneous
February	Noatak	1	[c] 5–50	5–50	0	5–50	5–50	0
March	Cape Thompson	3	5–50	5–50	5–50	5–50	<5	0
			5–50	5–50	0	5–50	<5	0
			5–50	5–50	0	5–50	<5	0
April	Cape Thompson	1	5–50	5–50	0	5–50	<5	0
May	Cape Thompson	2	5–50	5–50	0	5–50	0	0
			5–50	5–50	5–50	5–50	0	0
June	Colville	3	>50	<5	5–50	0	0	0
			>50	<5	0	0	0	0
			>50	>50	0	0	0	0
July	Colville	3	5–50	5–50	>50	0	0	0
			5–50	5–50	>50	5–50	0	0
			5–50	5–50	>50	5–50	0	0
August	Colville	2	5–50	<5	>50	<5	0	0
			<5	<5	>50	0	0	Fungi
September	Colville	2	5–50	5–50	0	>50	0	Fungi
			5–50	5–50	0	5–50	0	0
	Noatak	6	>50	<5	0	>5	0	Equisetum
			5–50	5–50	0	5–50	5–50	0
			>50	5–50	0	0	<5	0
			>50	5–50	0	5–50	<5	Equisetum
			>50	5–50	0	5–50	0	Equisetum
			5–50	5–50	0	5–50	<5	Equisetum
October	Colville	6	>50	5–50	0	0	0	Equisetum
			5–50	<5	0	>50	<5	0
			5–50	5–50	0	5–50	<5	0
			5–50	5–50	0	>50	<5	Equisetum
			>50	5–50	0	5–50	<5	0
			5–50	5–50	5–50	>50	<5	Equisetum
November	Cape Thompson	1	>50	5–50	0	0	<5	Fungi
		4	<5	5–50	0	>50	<5	Fungi
			5–50	5–50	0	5–50	<5	0
			5–50	5–50	0	>50	<5	Fungi
			<5	<5	0	>50	0	Fungi
December	Colville	4	5–50	>50	0	>50	0	0
			5–50	5–50	0	5–50	0	Fungi
			5–50	5–50	0	5–50	<5	0
			5–50	5–50	0	5–50	0	0

[a] Table 38, page 147, reference (*2*).
[b] Herbs, other than grasses and sedges.
[c] Value lies within the range indicated.

TABLE 5.—AVERAGE STRONTIUM-90 CONCENTRATIONS IN CARIBOU FLESH, ALASKA, 1960–1961[a]

Month	Number of caribou sampled	Strontium-90		
		pc/kg wet weight[b]	pc/kg dry weight	pc/g Ca[c]
1960				
August	5	3.7	13	37
October	3	9.7	39	97
November	3	7.6	29	76
1961				
February	2	6.0	22	60
March	7	8.8	38	88
April	2	13	56	130
May	1	2.7	10	27
June	5	4.7	20	47
July	4	6.1	24	61
August	4	6.6	24	66
September	4	7.7	30	77
October	3	7.7	31	77
November	6	9.3	68	93
December	5	9.6	38	96

[a] Table 41, page 152, reference (*2*) (modified).
[b] Frozen flesh.
[c] Assumed 100 mg Ca/kg wet flesh.

Their study (*5*) indicated that fish is a more important source of food than meat for Eskimos or Indians, and also that all Eskimos and Indians purchase part of their food in stores. Almost 60 percent of the dietary caloric intake was imported foods purchased at local stores. The dietary habits of residents of Northwestern Alaska, as characterized by the Committee on Environmental Studies for Project Chariot (*2*), showed certain special characteristics. For example, Point Hope Eskimos harvested, through hunting and fishing in 1960–1961, approximately 600,000 pounds of meat. This represented about 80 percent of the village's annual food requirements, the balance being imported. Of this total harvest, about 110,000 pounds was caribou meat, and the remainder consisted of marine and fresh-water fish and marine mammals (*2*). The above figures would indicate that about 65 percent of the total diet was composed of fish and marine mammals, and about 15 percent consisted of caribou meat.

Such information as is obtainable on the inland Eskimos indicates that a few groups are understood to eat caribou almost exclusively with some supplementation of fresh-water fish. Typical of these is a group located in the vicinity of Shungnak (*3*).

Information obtained from other studies[3] suggests that imported foods constitute a substantially larger proportion of the diets of Point Hope and Shungnak inhabitants than the foregoing figures would indicate. In contrast to the reports

[3] Unpublished information furnished by Dr. E. M. Scott, Arctic Health Research Center, Anchorage, Alaska.

TABLE 6.—STRONTIUM-90 IN SAMPLES OF ALASKAN CARIBOU[a]

Sample	Location	Collection date	Strontium-90 content		
			pc/kg wet	pc/g ash	pc/g Ca
Antlers	Arctic Tundra	1958		44	106
Antlers	Anaktuvuk River	Oct. 1959	4,250	107	281
Antlers	Anaktuvuk River	Oct. 1959	2,920	66	170
Antlers	Tulugak Creek	Oct. 1959	2,880	64	170
Meat	Anaktuvuk Pass	Nov. 1959	7.2		160
Stomach contents	Anaktuvuk River	Nov. 1959	3,550	110	1,260
Caribou-A					
Backbone	Shungnak	Feb. 1961		54	140
Leg bone				68	175
Meat				0.6	146
Stomach contents				104	2,970
Caribou-B	Shungnak	Mar. 1961			
Backbone				61	177
Leg bone				81	180
Meat				1.5	162
Stomach contents				135	3,440

[a] Table 3, reference (*3*).

TABLE 7.—CESIUM-137 IN ALASKAN CARIBOU FLESH, 1960–1961[a]

Location	Sampling date	Number of caribou sampled	Cesium-137 average (pc/gram wet wt. ± std. error)
	1960		
Cape Thompson	August	5	0.72 ± 0.58
Colville	August	3	2.0 ± 0.89
	October	4	9.7 ± 2.6
	November	2	8.9 ± 1.6
Cape Thompson	November	1	3.7
	1961		
Colville	February	1	15
Cape Thompson	February	1	1.7
	March	7	1.0 ± 0.20
	April	2	0.75 ± 0.08
Colville	May	1	8.2
	June	5	5.6 ± 1.5
	July	3	0.64 ± 0.09
	August	4	0.90 ± 0.14
Cape Thompson	August	2	1.3 ± 0.10
Colville	September	4	4.6 ± 0.26
	October	3	6.5 ± 0.80
	November	6	19 ± 1.8
	December	5	26 ± 0.80

[a] Table 39, page 150, reference (*2*).

cited (*2*, *3*), these unpublished studies show a lower percentage contribution of fish and marine mammals to the Point Hope diet, and a lower contribution made by caribou to the Shungnak diet.

Strontium-90 in Eskimos

The strontium-90 contents of a number of native bone samples collected between November 1959 and December 1960 are shown in table 8. Both childrens' and adults' bones are included among the samples. Most of the subjects involved in this sampling lived near or along the seacoast. These data did not indicate whether or how many of the subjects were natives of Northwestern Alaska.

Schulert (*3*) observed that the average strontium-90 to calcium ratio for the adult bone samples (0.5 pc Sr^{90}/g Ca) is somewhat above the average for the rest of North America (0.3 pc Sr^{90}/g Ca for adults). There were individual samples that were relatively high (1.9, 1.4, and 1.0 pc Sr^{90}/g Ca).

Lacking bone samples from predominantly caribou-eating Eskimos, urine samples were collected from six people in the Shungnak area for purposes of estimating exposure (table 9). An

TABLE 8.—STRONTIUM-90 CONTENT OF BONES FROM NATIVE ALASKAN CHILDREN AND ADULTS[a]

Age	pc Sr^{90}/g Ca
Single bones, November 1959–December 1960	
4 months	2.4 ± 0.3
7 years	3.4 ± 0.3
16	2.4 ± 0.1
20	1.0 ± 0.2
20	0.8 ± 0.2
20	0.6 ± 0.1
24	0.4 ± 0.1
24	0.7 ± 0.2
25	0.2 ± 0.1
26	0.4 ± 0.2
26	<0.3
26	<0.1
26	1.9 ± 0.2
29	0.4 ± 0.1
30	0.5 ± 0.1
30	<0.2
32	0.2 ± 0.1
33	0.7 ± 0.1
35	1.4 ± 0.1
36	<0.2
38	0.3 ± 0.1
38	0.3 ± 0.1
39	0.8 ± 0.1
40	<0.4
42	<0.4
44	0.4 ± 0.1
46	<0.4
46	<0.2
48	0.5 ± 0.1
53	0.4 ± 0.1
54	0.7 ± 0.2
54	0.3 ± 0.2
58	0.2 ± 0.1
60	0.8 ± 0.2
60	0.4 ± 0.1
60	0.4 ± 0.1
61	0.4 ± 0.1
62	0.5 ± 0.1
Average	0.7 ± 0.1

[a] Abstracted from Table 4, reference (*3*).

average strontium-90 to calcium ratio of 25 pc Sr^{90}/g Ca was found in these samples, with individual values ranging from 19.9 to 32.1 (*3*). Previous studies by Schulert indicated that the strontium-90 level in the diet was about twice that found in the urine (*6*). This relationship, coupled with an estimated strontium-90 discrimination factor of 4 for diet to bone, produced estimates of 50 pc Sr^{90}/g Ca in the diet and 12 pc Sr^{90}/g Ca in the bone of this caribou-eating group. Schulert notes that this estimated value is more than four times the U.S. average in 1961 (*3*).

TABLE 9.—STRONTIUM-90 CONTENT IN HUMAN URINE SPECIMENS FROM ALASKA, FEBRUARY 1961[a]

Sample	pc/liter	pc Sr^{90}/g Ca
1	4.7	23.4
2	10.2	32.1
3	5.2	19.9
4	4.0	21.1
5	5.6	31.6
6	3.4	22.1
Average	5.5	25.0

[a] Table 5, reference (*3*).

Cesium-137 in Eskimos

Measurement of total body burdens of cesium-137 in people living in the Alaskan Arctic were begun in the spring of 1962, utilizing a portable whole body counter described by Palmer (*7, 8*). Counts on more than 600 people, most of them Eskimos, were obtained by July 31, 1962 (*2*). Most of the subjects resided in Kotzebue, Point Barrow, and Anaktuvuk, an inland native village in the Brooks Mountain Range. Inhabitants of various other villages between Kotzebue and Point Barrow were also measured.

The whole body measurements (table 10) showed that residents of the Anaktuvuk Pass region had the highest cesium-137 body burdens due, probably, to caribou being a major source of their food. The average body burden of fifty-three permanent residents of this region was about 420 nanocuries (nc), and the maximum body burden found was about 790 nc.

TABLE 10.—CESIUM-137 IN HUMANS, 1962[a]

Residence	Number of samples	Average body burden (nc)	Maximum body burden (nc)
Anaktuvuk	53	420	790
Kotzebue			
Eskimos	150	140	500
Students	18	45	
Non-Eskimos[b]	29	35	
Non-Eskimos[c]	25	7	
Point Barrow			
Eskimos	256	40	170
Students	47	15	
Non-Eskimos[b]	2	40	
Non-Eskimos[c]	14	6	

[a] Data from page 154, reference (*2*).
[b] Consumed indigenous foods frequently.
[c] Consumed indigenous foods infrequently (about once per month).

Residents of Kotzebue and Point Barrow exhibited lower average cesium-137 body burdens, ranging from as low as 6 nc for non-Eskimo residents to 140 nc for Kotzebue Eskimos; the maximum in the latter group was 500 nc. In the case of the Kotzebue and Point Barrow residents, the cesium-137 body burdens of Eskimos who ate indigenous food regularly can be compared with those of two groups on non-Eskimo residents—those who ate indigenous food frequently and those who did not. Also given are values for Eskimo students who are away from the region part of the year. These data suggest that cesium-137 body burdens increase as indigenous foods constitute a larger part of the diet.

For comparison, available data (*9*) indicate that body burdens of cesium-137 in the U.S., determined in the first quarter of 1962, averaged 3.9 nc (29 pc Cs^{137}/g K).

Discussion

The apparent differences in the dietary patterns of coastal and inland Eskimos of Northwest Alaska suggest that the radionuclide intake from the indigenous food chains should be considered separately for each group. It is possible to derive rough approximations of the strontium-90 composition of the diets of the Eskimos in the two regions of this area by means of data available with respect to the concentrations of this radionuclide in the various food components comprising these diets. The only information bearing on this problem and available for this review is provided by the results of the 1960–1961 hunting and fishing harvest for the Point Hope Eskimos (*2*), a coastal group. An approximate average weighted concentration of 6.6 pc/kg wet weight of indigenous foods has been derived by computing the contribution made by the specific food items, multiplied by appropriate factors according to their strontium-90 concentrations.

Similar calculations on strontium-90 in the diet of inland Eskimos, if it is assumed that the diet is mainly caribou (as is said to be the case with certain Eskimos (*3*), would yield a weighted

average concentration of about 7 pc/kg, based on analyses reported for the period 1960–1961. Many inland Eskimos consume, in addition to caribou, considerable amounts of fresh-water fish. The latter have been shown to contain relatively high values of the radionuclide, as indicated in table 3, which shows a strontium-90 concentration of at least an order of magnitude greater than that for caribou (see table 5). These limited data suggest that the concentration of strontium-90 in the diet will increase as the consumption of fresh-water fish increases.

Data for cesium-137 concentrations in the diets of Northwest Alaskan Eskimos are meager. It has been found that the flesh of caribou sampled in a coastal area tended to be lower in cesium-137 concentration than flesh of caribou in an inland area (see table 7). Information of cesium-137 levels of other components of the Eskimo diets have not been available; therefore, it is not possible to evaluate the overall cesium-137 content of the respective Eskimo diets. Nevertheless, it is of interest that data on body burdens in two groups of Eskimos show relatively significant differences. As shown in table 10, the Anaktuvuk Eskimos, an inland group, exhibited substantially higher body burdens than were found in coastal Eskimos at Kotzebue and Point Barrow.

Strontium-90: Strontium-90 in the indigenous food chain in Northwestern Alaska is compared below to the Federal Radiation Council (FRC) intake guidance values. The Radiation Protection Guide (RPG) of the FRC (*10*) for *bone marrow* is 0.5 rem per year for individuals in the general population and 0.17 rem per year for an average of suitable samples of an exposed population group. The RPG for strontium-90 in mineral bone is based on the fact that the dose rate to bone from strontium-90 is three times the average dose rate to bone marrow for a given bone burden. Therefore, the RPG for *mineral bone* is 1.5 rem per year for individuals in the general population and 0.5 rem per year for the average to be applied to a suitable sample of an exposed population. The FRC stresses that the above RPG's, under normal peacetime conditions, represent an appropriate balance between benefit and risk.

Further, the FRC has established ranges of daily intake for strontium-90. Intakes between 20 and 200 pc per day (FRC Range II) would call for active surveillance and routine control and intakes up to 20 pc per day (FRC Range I) would call for routine surveillance.

Strontium-90/calcium ratios in bone have been used for determining the radiation dose from strontium-90 in a population. However, these ratios in adult bone can differ substantially from those in child bone. The difference may be attributed to two primary factors: (1) variation in the rate of calcium deposited in bone with the age of the individual and (2), whether the person was born some time prior to or after strontium-90 appeared in the environment. During the growth stage, calcium (and strontium) is deposited in bone at a much faster rate than during the adult stage in which calcium (and strontium) deposition occurs only as a result of remodeling and some mineral exchange. Since calcium (and strontium) is deposited at a much faster rate in children than in adults, children born after nuclear tests were first conducted would be expected to have higher strontium-90/calcium ratios in bone than adults would. Some indication of this relationship appears in table 8. This presupposes conditions where adults and children follow the same dietary intake patterns and live in the same geographical areas.

For the above reasons, the use of strontium-90/calcium ratios for adult bone would lead to low estimates of radiation doses from strontium-90 in children.

The higher of the two strontium-90/calcium ratios for children in table 8, 3.4 pc/g Ca, might be attributed to a continued dietary intake of about 14 pc per day assuming a discrimination factor of 4 from diet to bone (*10*), and assuming a daily intake of one gram of calcium. A daily intake of about 14 pc per day, derived from this single bone sample, represents strontium-90 intakes in FRC Range I. This calculated value reflects dietary intake of strontium-90 up to some point in time between November 1959 and December 1960.

In making the above comparison between data from bone analyses for strontium-90 and radiation protection guidance values, one must keep in mind that the relationships between intake and body burden or dose are based on constant environmental radionuclide levels throughout life.

Cesium-137: The FRC has stated (*11*) that the characteristics of cesium-137 permit direct comparison of doses received from this radionuclide with recommended whole body exposures. This same authority recommends that the average whole body dose in an exposed population group should not exceed 170 mrem per year (*12*). This value has been selected in order to insure that the

whole body dose to the individual is less than 0.5 rem per year, the appropriate RPG.

Referring to the recommendations of the International Commission on Radiological Protection (*13*), a body burden for cesium-137 of 3,000 nc for an individual in the exposed population would correspond to a whole body dose to the individual of 0.5 rem per year. A whole body burden for cesium-137 of 1,000 nc would produce a yearly dose of 170 mrem, the whole body Radiation Protection Guide for the average population.

Thus, the maximum individual body burden in table 10, 790 nc, would represent about one-fourth of the appropriate RPG of 0.5 rem. Similarly, the highest average body burden of 420 nc in the same table represents about two-fifths of the appropriate RPG of 170 mrem for a population.

Summary

Recent findings in radionuclides in the indigenous foods chain (vegetation-diet-man) for Northwestern Alaska in 1959–1961 have been briefly reviewed. Lichens, moss and sedges, among vegetation sampled, appear to concentrate certain radionuclides to a greater extent than do other forms of vegetation in Northwestern Alaska. Certain features of the diets of various inland and coastal Eskimo groups have been presented, and some relationships have been examined between the various components of indigenous foods and their contributions of strontium-90 and cesium-137 to the native diets. It is calculated from available data that the intake of strontium-90 up to December 1960 falls within FRC Intake Guidance Range I. In the case of cesium-137, it has been found that the highest average body burden reported represents about two-fifths of the appropriate RPG of 170 mrem for a population.

Acknowledgments

Permission to reproduce portions of the tabular material from reference (*3*), presented herein in tables 3, 6, 8, and 9, had been kindly granted by Dr. A. R. Schulert, author, and Dr. P. H. Abelson, Editor of *Science*. Special acknowledgment is extended to Miss Virginia J. Croft, Editorial Assistant, for her invaluable help towards assembling this review.

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(*12*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, Memorandum for the President, *Federal Register*, pp. 4402–3 (May 18, 1960).

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Environmental Levels of Radioactivity of Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Various summaries of the environmental radioactivity data for 22 AEC installations have appeared in *Radiological Health Data* since November 1960. Summaries follow for the National Reactor Testing Station and the Pinellas Peninsula Plant for the calendar year 1962.

The measured concentrations of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in the National Bureau of Standards "Handbook 69" (*1*). Some of the appropriate MPC's are given in table 1.

To avoid any possible misunderstandings in the use of the term "Maximum Permissible Concentrations," the Federal Radiation Council (FRC) has recommended the term "Radioactivity Concentrations Guide" (RCG) for the use of Federal agencies. Although FRC has not published a complete table of RCG values, several AEC installations, such as the National Reactor Testing Station, have adopted FRC nomenclature but use the values published by the NCRP, except for those nuclides such as iodine-131 and strontium-90, for which FRC guidance has been given. For a more detailed description of the meaning and use of the RCG, the reader is referred to FRC Reports No. 1 and No. 2 (*2*, *3*).

The establishment of MPC's does not imply that each nuclide may be permitted to be present at 100 percent of its MPC concentration. If the concentration of each nuclide is expressed in terms of percent of its MPC, the sum of all the percent values should not exceed 100 percent.

In the following reports, nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low, a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value. References, by line, to table 1 will be made to designate the appropriate MPC's reported by the laboratory.

REFERENCES

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(*2*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 1*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (May 13, 1960), price 30 cents.

(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.

TABLE 1.—SELECTED ENVIRONMENTAL VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line no.	Radionuclide or mixture of radionuclides	Environmental MPC's (or RCG)	
		Water ($\mu\mu$c/liter)	Air ($\mu\mu$c/m^3)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[a]	—	10.0
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[a]	—	100
8	Hydrogen-3: tritium oxide (H_2^3O)	3,000,000	200,000
9	Hydrogen-3: tritium gas (H_2^3)	—	40,000,000
10	Iodine-131	[b]100	200
11	Strontium-90	[b]200	10

[a] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to recent AEC regulation (*Federal Register*, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

[b] These RCG values were adopted by the National Reactor Testing Station for its guides.

NATIONAL REACTOR TESTING STATION
Calendar Year 1962

Health and Safety Division
Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Stations (NRTS) is located in a very remote area which, in a large measure, permits controlled releases of radioactivity from the projects with minimum risk to the environs.

Responsibility for holding the environmental radioactivity levels at the station below the Radiation Protection Guides (RPG) recommended by the Federal Radiation Council (FRC) lies with the Atomic Energy Commission. One of the safeguards employed is a monitoring program. Descriptions of the monitoring network procedures have been presented in earlier issues. Quarterly environmental monitoring results, in addition to calendar year averages for 1962, are shown in table 2. Sampling locations at NRTS can be seen in figure 1.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*November 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*May 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters and calandar year 1961	*June 1962*

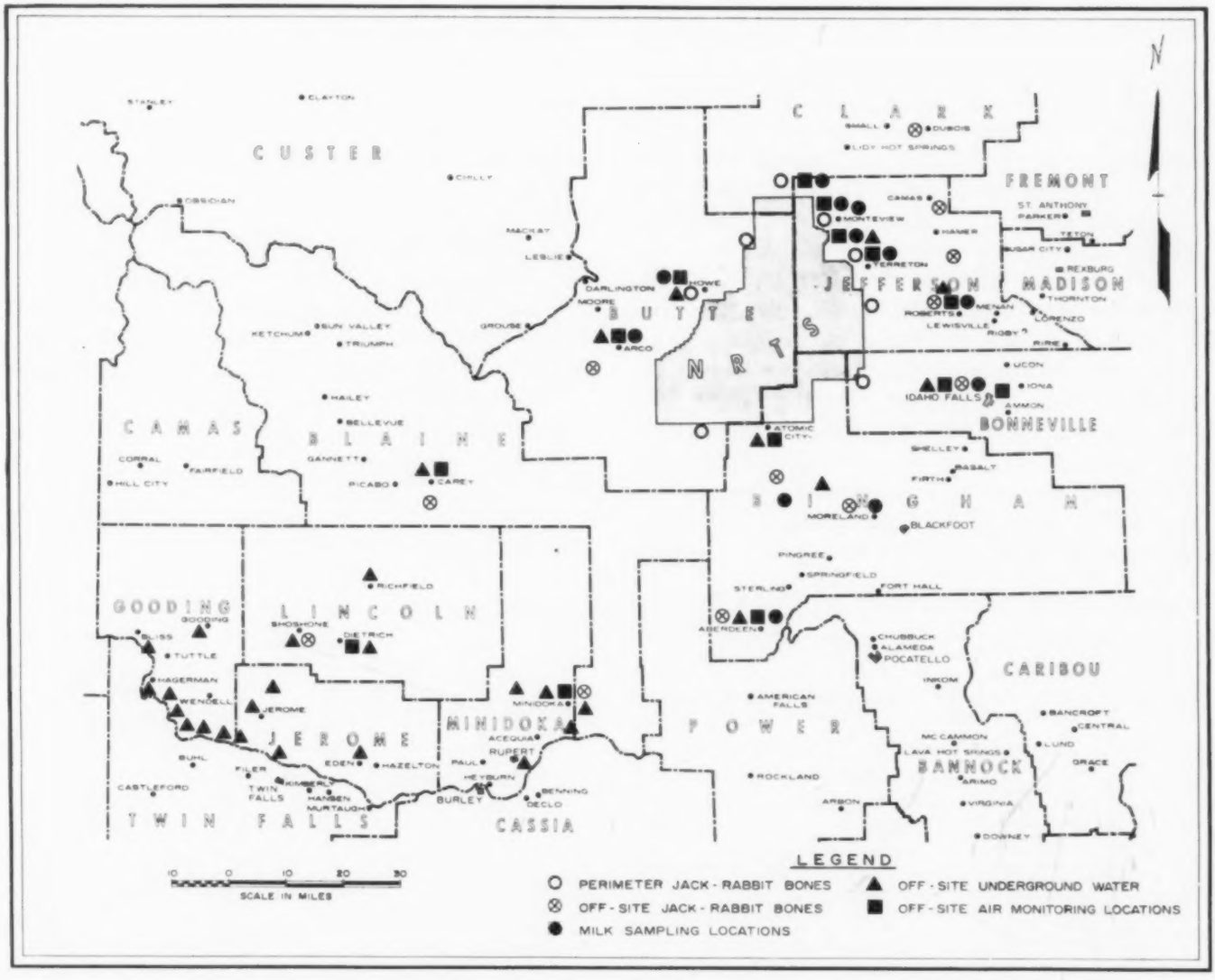

FIGURE 1.—ENVIRONMENTAL MONITORING STATIONS, NATIONAL REACTOR TESTING STATION

TABLE 2.—ENVIRONMENTAL MONITORING PROGRAM DATA, NRTS, 1962

Type of sample and units	No. of stations	Approximate frequency of collections	Type of analysis	Minimum level of detection	1962 Quarterly averages				1962 Calendar year summary
					First quarter	Second quarter	Third quarter	Fourth quarter	
Off-site underground water ($\mu\mu$c/liter)	30	3 months	α	3	<3.0	<3.1	<4	<3	<4
			β	[a]6	<150	<50	<30	<20	<100
			H^3	4,000	<4,000	<4,000	<4,000	<4,000	<4,000
On-site production well water ($\mu\mu$c/liter)	21	2 weeks	α	3	<3.1	<3.1	<3	<4	<3
			β	[a]6	<150	<130	<50	<20	<100
			H^3	4,000	<5,900	<5,600	<6,000	<6,000	<6,000
Off-site air filters ($\mu\mu$c/m^3)	14	1 week	β	(not given)	13	13	13	26	16
Off-site milk ($\mu\mu$c/liter)	10	1 month	I^{131}	[b]10	<50	<50	<65	<70	<60
	8	2 months	Sr^{90}	1.5	7	8	13	8	9
Off-site area monitoring badges (mrem)	14	6 weeks	γ	10	<20	<20	[c]no data	<20	<60
			β	10	<20	<45		<20	<85

[a] Changed from 50 to 6 in October 1962.
[b] Changed from 50 to 10 in September 1962.
[c] Film badge data not available for third quarter due to defective film.

PINELLAS PENINSULA PLANT
Calendar Year 1962

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant (PPP), shown in figure 2, is an electronic component production facility in the Atomic Energy Commission's Albuquerque Operations Office manufacturing complex. Environmental monitoring includes sampling of a single combined sewer effluent, milk from five local dairy farms, air, and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples which may contain tritium gas, the

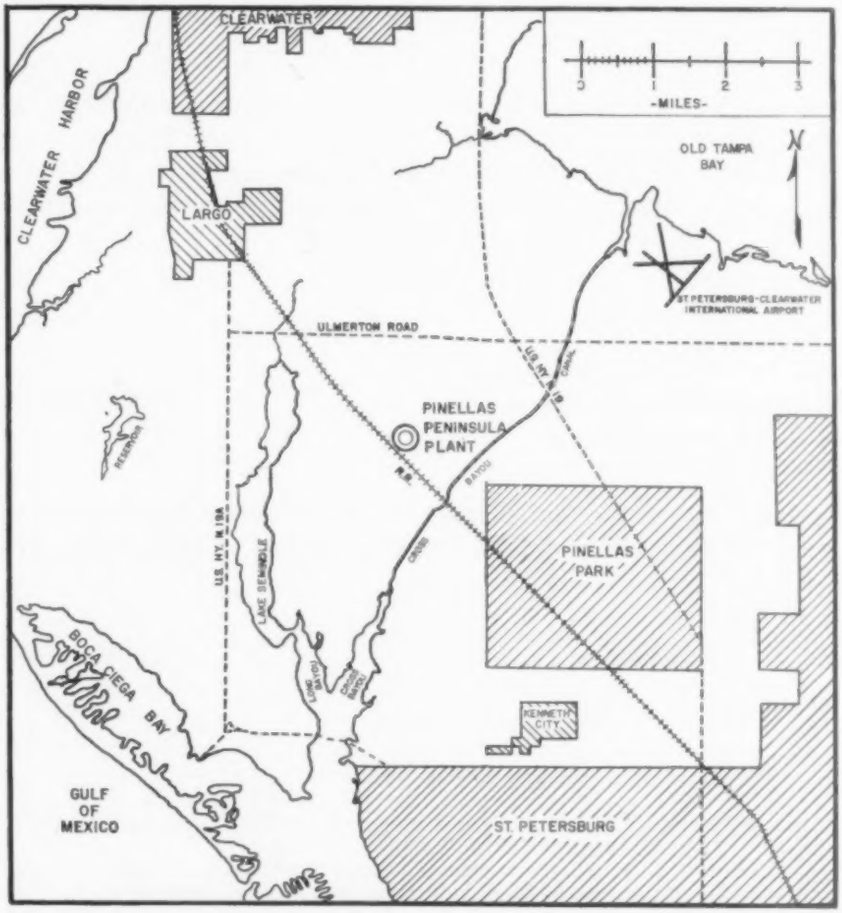

FIGURE 2.—LOCATION OF THE PINELLAS PENINSULA PLANT SITE

radioactive portion of the samples is essentially tritium oxide.

Air Monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack, where maximum ground level concentrations would be expected. During the entire year, air sample analyses revealed no detectable concentrations of tritium gas ($<1{,}300{,}00$ $\mu\mu c/m^3$ of air) or tritium oxide ($<5{,}000$ $\mu\mu c/m^3$ of air).

Water Sampling

A combined sewer effluent sample is obtained daily from beyond the perimeter of the plant's property. During the year, there were no detectable concentrations of radioactivity ($<120{,}000$ $\mu\mu c$/liter) in the 246 samples taken.

Surface water samples are normally obtained during the last week in each month at locations within 6 miles of the plant. These points are determined by radioactivity discharges in the exhaust stack effluent and meteorological data. In the event of accidental discharge of significant amounts of tritium, samples are obtained at the point of maximum ground deposition during or immediately following such discharges. There were no indications of tritium in 100 surface water samples analyzed during the year.

Milk Sampling Results

Fifty samples of raw milk were taken from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1962. No detectable concentrations ($<120{,}000$ $\mu\mu c$/liter) of tritium were evident.

Previous coverage in *Radiological Health Data:*

Period	Issue
1960–1961	*July 1962*

Reported Nuclear Detonations

May 1963

One nuclear detonation was announced by the Atomic Energy Commission for the month of May. This test, conducted underground on May 22 at the Nevada Test Site, was of intermediate yield. (The AEC has annouced the intermediate yield range as being from 20 kilotons to 1 megaton.) *Radiological Health Data* has assigned the test the arbitrary reference number of 103.

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UNITS AND EQUVALENTS

For the convenience of the *Radiological Health Data* (*RHD*) reader a selected list of units and equivalents is presented below.

Symbol	Name	Equivalent
Bev	billion electron volts	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	precipitation: $\text{mm} = \frac{\text{m}\mu\text{c/m}^2}{\mu\mu\text{c/liter}} \times 1000 = \frac{\text{liter}}{\text{m}^2}$
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 $\mu\mu$c = 10^{-12} curies
r	roentgen	
$\mu\mu$c	micromicrocurie	1 $\mu\mu$c = 2.22 dpm

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